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BLACK HOLE MYSTERY

The first supermassive
black holes formed earlier
than seems possible.

What are scientists missing?

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Illustration by Mark Ross.

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Go to www.ScientificAmerican.com/feb2018/ai-et

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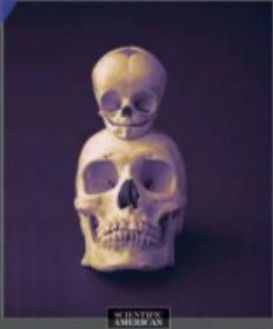
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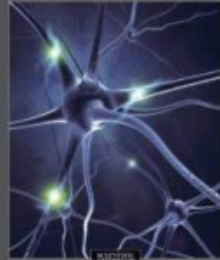
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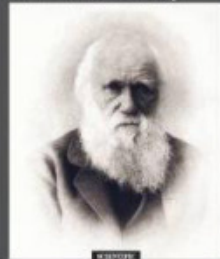
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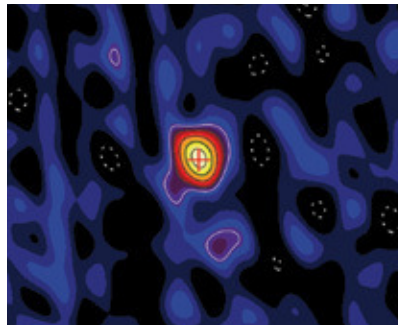


Mariette DiChristina is editor in chief of *Scientific American*. Follow her on Twitter @mdichristina

Depths of Space, Oceans and Politics

Looking at the very distant, very ancient universe, we find quasars—extremely bright cosmic lights powered by gas falling onto supermassive black holes. But how could black holes have been able to grow so large in such a short time after the big bang? Theory holds that a black hole is the product of a collapsed elderly, burned-out star. So it doesn't make sense to see such massive ones so early in the timeline of our universe.

Unless, of course, there is another way for black holes to arise. Instead of being born from dying stars, could the seeds of the most ancient of these humongous black holes have collapsed directly from the glass clouds in the early universe? An answer could be coming soon. The James Webb Space Telescope, which is due to launch in 2019 and will be able to peer farther back in spacetime than any previous instrument, could find proof of such direct-collapse black holes. Find out how in our cover story, “The First



HOST GALAXY of a newly discovered quasar, evidence of supermassive black holes in the early universe.

Monster Black Holes,” by astrophysicist Priyamvada Natarajan, starting on page 24.

If we first viewed our planet from the perspective of outer space, it's been said, we would have named it “Ocean” instead of “Earth.” Ocean health is intimately linked to the well-being of countless species, which is why more than 15,000 marine protected areas exist worldwide. The regulations often permit oil drilling and commercial fishing, however—a cause for concern, reports journalist Olive Heffernan in “Troubled Waters.” Turn to page 44 to find out how nations need tougher rules close to shore to improve fisheries and biodiversity.

I suspect I'm far from alone in my dismay at the increasingly coarse, antagonistic tone of U.S. political discourse. Worse, the rise of polarization is not just unpleasant. It is also raises the question of “what happens in our minds—and to our minds—” when we argue only to win, write cognitive researchers Matthew Fisher, Joshua Knobe, Brent Strickland and Frank C. Keil. Their article, beginning on page 50, spells out “The Tribalism of Truth.” Truth, of course, relies on data—which haven't always been in plentiful supply from the Food and Drug Administration. In “[Redacted],” journalist Charles Seife explores how drug data

have gone missing vis-à-vis big pharma (page 38). In this, the “information age,” we as patients—and citizens in general—need all the transparency we can get. **SA**

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October 2017

CONGRESSIONAL AMATEURS

In “Put Science Back in Congress” [Science Agenda], the editors advocate for a non-binding science advisory board to educate Congress on scientific issues. The problem, however, is much deeper. Having congressional committees such as the House Committee on Science, Space, and Technology composed of nonscientists is in itself quite ridiculous. And most of the people on them don’t even want to be advised about science. They surely wouldn’t take any advice seriously. The very least that is needed is a blue-ribbon panel of real scientists.

Further, the editors suggest that “industry representatives” can “still have a voice” but should “counsel the committees separately.” There is no need to include such nonscientist representatives. They are only thinking about their profits.

Science is not a debate society where sophistry is more important than facts and evidence. I urge *Scientific American* to take a much stronger stance against science deniers.

JOHN JAROS Philadelphia

GUNS AND CRIME

Melinda Wenner Moyer’s article “Journey to Gunland” ignores virtually all of the literature on right-to-carry laws and gun ownership since 1998. About two thirds of the peer-reviewed, published literature show that concealed-carry laws help to reduce crime. I provided Moyer with those

“Science is not a debate society where sophistry is more important than facts and evidence.”

JOHN JAROS PHILADELPHIA

papers, but she doesn’t give a single reference to them, and she appears unaware of any of my research after 1998.

Moyer quotes physician Garen Wintemute: “Few studies ... suggest that liberalizing access to concealed firearms has ... beneficial effects.” But she ignores 24 peer-reviewed publications just showing that crime in the U.S. drops after people are allowed to carry concealed handguns.

Take one example of Moyer’s bias: She has a long discussion about Arthur Kellermann’s work on the risks of guns in the home and says that Kellermann studied “444 people who had been killed between 1987 and 1992 at home.” But she fails to note that in *only eight of these 444 homicide cases* was the murder weapon a gun that had been kept in the home.

JOHN R. LOTT, JR. *President,*
Crime Prevention Research Center

MOYER REPLIES: *My investigation involved far more than the impact of concealed-carry laws and ultimately concluded that more guns—period—are associated with more crime and violence.*

Lott’s claim that two thirds of the literature show that concealed-carry laws help to reduce crime comes from a 2012 paper he wrote for the Maryland Law Review. It asserts that 18 of 29 studies showed that result. One third of those citations refer to his own work, and many of the studies are off-topic in that they do not evaluate concealed-carry laws at all. Lott also omits peer-reviewed studies that belong on the other side. And included among the 24 papers he refers to, which are listed on his Web site, are the irrelevant papers mentioned above, as well as other studies that do not show links between concealed-carry policies and low crime.

Finally, the Kellermann study found the odds of being murdered nearly tripled

among those who kept guns at home. Lott says it is important that most of these homicides did not involve the resident’s gun, but it is not. The study was designed to assess the relation between keeping a gun in the home and the risk of being murdered by any weapon. Murder victims are murder victims, regardless of weapon or means. EDITORS’ NOTE: This exchange between Lott and Moyer was edited for space. Readers can examine Lott’s research studies at <http://bit.ly/2ipGERA>; the full letter and reply are available at www.ScientificAmerican.com/gun-debate

HYGIENE CREDITING

“Dangerous Medicine,” an excerpt of Lindsey Fitzharris’s book *The Butchering Art*, ends by justly celebrating Joseph Lister’s lifesaving work in elucidating and fighting postoperative infection. But it is troubling that it fails to note the earlier, disregarded discovery of antisepsis by Ignaz Semmelweis. It has become sadly customary to fault cantankerous, self-assured scientific pioneers for the failure of their benighted contemporaries to recognize their genius. The tragic delay in implementing antisepsis should remind us of our obligation to see truth for what it is, regardless of the social niceties of the creative genius.

JEFF FREEMAN *Rahway, N.J.*

FITZHARRIS REPLIES: *Ideas are never created in a vacuum, and Lister’s life very much attests to that truth. I discuss Semmelweis, as well as many other medical practitioners working in parallel with Lister, in my book. That said, Semmelweis’s methods and theories had little impact on the medical community during his lifetime. Lister visited a clinic in Budapest where the beleaguered physician had recently worked and later reflected that “Semmelweis’s name was never mentioned to me having been, as it seems, entirely forgotten in his native city as in the world at large.” It should also be said that Lister’s contribution wasn’t his discovery of antisepsis; rather it was his application of germ theory to medical practice through the systematic implementation of antisepsis.*

CONQUISTADOR OF THE COSMOS

In “Sky Gods for Skeptics” [Skeptic], Michael Shermer quotes an earlier column

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in which he said that “any sufficiently advanced extraterrestrial intelligence [ETI] is indistinguishable from God.” How advanced is “sufficiently” advanced, and which observer determines it? And for whom is it “indistinguishable”? An iPhone-worshipping Neandertal?

Also, clerics usually assign to God the attributes of mercy, even regret and anger, which are obliquely if at all related to intelligence. How can an all-knowing being regret anything? Would Shermer’s God-like ETI thus lack mercy or regret or need to control anger?

ROBERT N. TAUB *Retired professor of medicine, Columbia University*

SHERMER REPLIES: First, I seriously doubt that an omniscient, omnipotent and, especially, omnibenevolent deity would have human emotions like anger and regret. Second, the example of an awestruck Neandertal bewildered by an iPhone would seem to fulfill most people’s criteria for sufficiently advanced technology, but obviously this is not yet a testable hypothesis.

Third, Italian astronomer and mathematician Claudio Maccone has developed a mathematical equation to measure the amount of information and entropy representing different civilizations throughout history and compared them with what an alien civilization a million years more advanced than ours might be like.

For example, he computed that the difference between the Aztecs and the Spanish in their first encounter in 1519 was 3.84 bits of information per individual over around 5,000 years of technological difference. And he calculated the difference between our civilization and an alien one a million years more advanced as 10,000 bits per individual. Given how easily the Spanish conquered the Aztecs, such an alien civilization would not only seem God-like but could prove catastrophic for us if its members did contain those human emotions.

CLARIFICATION

“The Neutrino Puzzle,” by Clara Moskowitz, refers to most particles, including protons and neutrons, acquiring mass by interacting with the Higgs field. Protons and neutrons do not directly interact with the field, but their constituents, quarks, do.

Go Public or Perish

When universities discourage scientists from speaking out, society suffers

By the Editors

Opioids. Fracking. Zika. GMOs. Scientists should be speaking up about all sorts of science-based issues that affect our lives. Especially now, when Trump administration officials tell us that climate change is debatable and that killing African elephants can benefit the herd, scientists should be constantly exposing misinformation, bogus alternative facts and fake science.

Unfortunately, the greatest obstacle to informing the public may be the very universities that many scientists work for.

When *Scientific American* editors talk with Ph.D. students, postdoctoral researchers and early-career scientists, they often tell us that an adviser or senior department member has instructed them not to write blogs or articles for the general public, speak at public events or talk with reporters and to stay away from social media. In a 2016 survey of 61 chairs of U.S. and Canadian medical departments, only 23 percent said it was important for faculty to participate in blogs hosted by *medical journals*. Never mind personal blogs and those in the media.

These activities, they are told, are a waste of time because they do not count toward attaining tenure or promotions. The only things that count are publishing research in respected journals, getting grants, teaching and serving on a university committee. Forget the rest of society.

This message is delivered most strongly to young scientists, who are striving to build a career and are passionate about improving the world. Older scientists also tend to stay silent because it has been ingrained in them to do so. Yet if these individuals would write popular articles, appear on radio and television, or post their insights on blogs and social media, scientists as a group would have far more influence than they do today.

Some veteran scientists are starting to criticize this system, in part because it allows politicians, corporations and science deniers to hijack public scientific discourse. For example, Jonathan Foley, who serves on *Scientific American's* board of advisers and who held influential university positions before becoming executive director of the California Academy of Sciences, has come out swinging. In an online essay he states that science communication is "a moral imperative." Too many scientists, he writes, "view science communication, outreach, and engagement with disinterest, disdain, or even contempt." He adds that a scientist's job is not to "crank out obscure academic publications by the dozens, and amass a long list of peer citations.... As scientists, your *real* job should be to make great discoveries and share them with the world."



Organizations that fund science or represent scientists are beginning to encourage greater public interaction. The National Science Foundation now requires grant applicants to address the broader impacts of the proposed work, part of which is public outreach and education. In 2016 the American Geophysical Union published a statement saying that its 60,000 members have a responsibility to communicate their findings and to respond to inaccurate portrayals of science. And a 2016 report from the American Sociological Association recommended that universities include public engagement in academic promotion criteria, noting that outreach not only benefits society but also can raise a school's public profile.

If universities do not modernize their tenure and promotion policies, these good starts may accomplish little. A handful of universities have begun to change. The Georgia Institute of Technology, for example, is discussing ways to recognize outreach when assessing promotions and is considering a prize for faculty who do it well. The institute is also planning to teach scientists the skills needed to write and speak publicly. So is Michigan State University. Changes are under way at Virginia Tech, the University of Minnesota and other institutions.

These moves are encouraging. Many more schools should follow suit. That will require academic administrators and faculty leaders to change their attitudes. Survey after survey shows that people worldwide respect scientists highly. But if citizens never hear from these legitimate experts, no one can blame them for indifference to fake-science tweets, decisions by politicians that ignore facts, or cuts to federal agencies that are supposed to be built on sound science. ■

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A Universal Flu Vaccine Is Vital

A century after the deadly pandemic of 1918, we're still not safe

By Catharine I. Paules and Anthony S. Fauci

This year the world will mark the 100th anniversary of one of the most devastating infectious disease events in recorded history: the 1918 influenza pandemic, which caused an estimated 50 million to 100 million deaths worldwide.

There were several reasons for the awful toll. First, most people likely had no preexisting immune protection to the brand-new strain that had emerged. Second, this particular virus may have been unusually lethal. Third, crowding and poor sanitation allowed for rampant disease transmission, especially in regions where access to health care was limited. And finally, antiviral drugs and flu vaccines were still decades in the future.

Over the past century we have made substantial advances in all these areas. But we are still unprepared for the inevitable appearance of a virus like the one that struck a century ago. Even an ordinary seasonal flu epidemic will still kill some 12,000 to 56,000 people every year in the U.S. alone. That is because seasonal viruses continually evolve, and although we update our vaccines frequently, they may be only 40 to 60 percent effective. Moreover, seasonal vaccines may provide little or no protection against pandemic flu. Pandemic viruses typically arise from a process referred to as an antigenic shift, in which the new virus acquires, usually from animal influenza viruses, one or more genes that are



Catharine I. Paules is a medical officer in the Office of the Director at the National Institute of Allergy and Infectious Diseases. **Anthony S. Fauci** is director of the National Institute of Allergy and Infectious Diseases.

entirely novel (as seems to have happened in 1918, when all eight pandemic virus genes were novel).

In the years since 1918, three influenza pandemics associated with antigenic shifts occurred: in 1957, 1968 and 2009. In each of these instances, however, the new viruses emerged via the mixing of animal influenza virus genes with those of the 1918-descended viruses already circulating in the human population, which meant that many people were at least partially immune. That, plus lower viral pathogenicity and improvements in public health infrastructure and medical treatment, is what probably led to less catastrophic pandemics.

We must also tackle the issue of “prepandemic” influenza viruses—those that could potentially cause pandemics but that have not (yet) done so. Human infections with avian influenza viruses have occurred with increasing frequency over the past two decades. Prepandemic vaccines against various strains of H5N1 and H7N9 viruses have been developed and in some cases stockpiled; similar to seasonal influenza viruses, however, these avian strains are subject to antigenic drift within their avian hosts. Many of the H7N9 avian viruses that have jumped species from poultry to cause human infections in China in 2016 and 2017 have changed significantly from 2013 avian strains. As a result, the human immune responses elicited by a vaccine developed against the 2013 H7N9 virus may not be effective against 2017 strains.

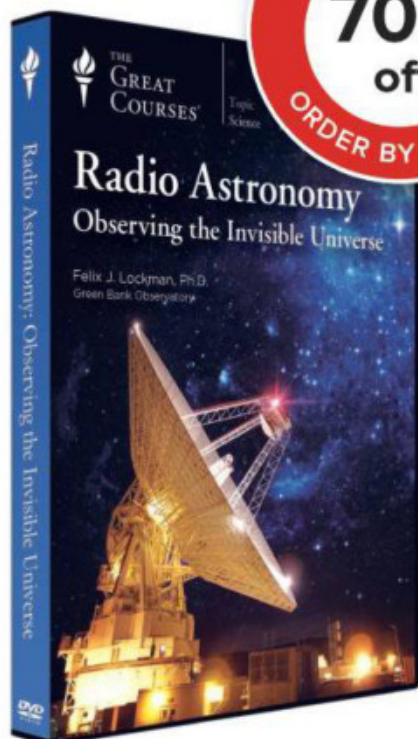
The remarkable capacity of influenza viruses to undergo antigenic drift or shift to overcome and escape human population immunity leaves us vulnerable to a public health disaster potentially as serious as the 1918 pandemic. To meet this global health challenge, scientists are working to develop “universal influenza vaccines”—new types of inoculations that can provide protection not only against changing seasonal influenza viruses but also against the inevitable pandemic viruses that will emerge in the future.

Recently the National Institute of Allergy and Infectious Diseases convened a workshop with leading experts in the influenza field to address the need for better influenza vaccines. Among many obstacles to developing a universal vaccine, the most formidable is our incomplete understanding of the immune responses that protect people against influenza, including the role of immunity at mucosal surfaces.

One approach is to design a vaccine to generate antibody responses to parts of the virus that are common to all influenza strains and do not readily change by mutation. It is also crucial to clarify how other parts of the immune system work together with antibodies to protect against influenza. The hurdles in the development of such vaccines are daunting. But we are optimistic that we can apply existing tools and experimental strategies to meet the challenge. As we note the centennial of the 1918 flu pandemic, let us remind ourselves of the importance of this line of research in preventing a repeat of one of the most disastrous events in the history of global health. ■

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Pull Back the Curtain on the Unseen Universe

For a few hundred thousand years, we used our eyes as our primary astronomical tool. But all that changed in the 1930s when a young engineer named Karl Jansky detected radiation below the visible part of the spectrum emanating from an astronomical object—and radio astronomy was born.

Radio Astronomy: Observing the Invisible Universe takes you on a thrilling journey through astounding discoveries and a virtual tour of the world's most powerful radio telescopes with Felix J. Lockman, Ph.D., of the Green Bank Observatory as your guide. But perhaps the most astounding of all radio astronomy discoveries is this: The dominant molecular structures in interstellar space are based on carbon. That is not what scientists had expected. We have always labeled these molecules “organic” because life on Earth is carbon based. Now we know the chemistry of the entire Milky Way is organic, not just our home planet, and it is likely that any extraterrestrial galactic life would be related to us, at least on the molecular level. Will we find other organic life forms out there? Radio astronomers don't know. But they're certainly working on it.

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ADVANCES



The Mediterranean by night: The world's artificially lit area has increased by at least 2.2 percent annually in recent years, satellite data suggest.

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GEOSCIENCE

The End of Night

An increasing proportion of the world is becoming artificially lit

Artificial light is often seen as a sign of progress: the march of civilization shines a light in the dark; it takes back the night; it illuminates. But a chorus of scientists and advocates argues that unnaturally bright nights are bad not just for astronomers but also for nocturnal animals and even for human health.

Now research shows the night is getting even brighter. From 2012 to 2016 the earth's artificially lit area expanded by an estimated 2.2 percent a year (*map*), according to a study published last November in *Science Advances*. Even that increase may understate the problem, however. The measurement excludes light from most of the energy-efficient LED lamps that have been replacing sodium-vapor technology in cities all over the world, says lead study author Christopher Kyba, a postdoctoral researcher at the German Research Center for Geosciences in Potsdam.

The new data came from a NASA satellite instrument called the Visible Infrared Imaging Radiometer Suite (VIIRS). It can



COURTESY OF NASA EARTH OBSERVATORY; IMAGES BY JOSHUA STEVENS, USING SUOMI NPP VIIRS DATA FROM MIGUEL ROMÁN AND NASA'S GODDARD SPACE FLIGHT CENTER

FIRST OR BEST: A NEW ETHOS FOR DRUG DEVELOPMENT

A conversation with **DAN SKOVRONSKY**, the next president of Lilly Research Laboratories



Two years ago, Lilly made a bold statement. The drug company declared it would launch 20 new medicines in a 10-year timeframe. It was an ambitious goal — and one that Dan Skovronsky intends to fulfill under a new role starting in June 2018 as president of Lilly Research Laboratories, the research and development arm of the 141-year-old pharmaceutical company.

Do you really think 20 new medicines between 2014 and 2023 is possible?

Absolutely. We're committed to that. We have nine launched in this window already, and one more under regulatory review. So we could soon be halfway through our 20. It's an extremely ambitious target, though. If you look at Lilly's history, we've never even come close to 20 medicines in a 10-year period. Our average productivity is half that, which means we're already in record territory. This is a historic time for Lilly and we think we can keep up this pace.

What makes Lilly Research Labs different from other R&D hubs in the pharmaceutical industry?

Lilly has been in essentially the same business of making medicines in Indianapolis for more than 140 years. This is the company that brought insulin to patients. We were one of the biggest producers of the polio vaccine. We were responsible for many of the innovations in antibiotics, and more recently advances in oncology and neuropsychiatric medications. So, we have this uninterrupted legacy of innovation fueling our business and I think that's pretty unique in our industry.

How do you expect Lilly Research Labs will change under your leadership?

One thing I'm focusing on,

together with our new CEO Dave Ricks, will be medicines that are either first-in-class or demonstrably best-in-class. The era of medicines with incremental improvement is coming to a close, and increasingly we'll see that the successful companies in our business are those that can drive breakthrough innovations for patients. That's our mission at Lilly, and that means we'll have to address more novel biology. It will also probably mean smaller trials in early development looking for big signals. If we don't see those big signals, we'll just move on, because we know there are so many opportunities out there. When we do see signs of a game-changer, that's when we'll go all-in and really invest fully because we know it could be a great medicine for patients.

You come from the Alzheimer's field, which has been plagued by failure, including for Lilly in drugs such as solanezumab, the anti-amyloid therapy. Do you have the stomach to keep at it in Alzheimer's?

We still see Alzheimer's as one of the largest unmet medical needs, and we, as a company and an industry, are closer than ever to turning the tide of this devastating disease. We know more about Alzheimer's than we did in the past, and part of that comes from lessons that

we learned from our own clinical trials. It's easy, in retrospect, to point out the things we wish we'd done better, but often the science and technology wasn't there. With solanezumab, it was the first time anyone had done a phase 3 trial where all of the patients actually had amyloid pathology in the brain. No one thought that was possible before we did it, but now nearly every trial in the industry does that. Still, we know that's not enough.

Fortunately, we're getting much more sophisticated, with the ability to track disease pathology in patients and with investigational medicines that actually can remove or prevent the pathology. I'm optimistic for the field, and our commitment to Alzheimer's is strong.

Lilly has had better success with cancer treatment, but the company is not at the forefront of immuno-oncology. Is that a concern?

Every company in our industry wishes they had one of the first checkpoint inhibitors — it's obviously an important advance. But we also see immuno-oncology as still being in its very early stages, and our goal is to lead the next generation of immunotherapies, maybe even to leapfrog competitors. We have a number of different approaches that we're testing in patients, including combinations of promising targets.

What other therapeutic areas will you be focusing on?

Diabetes is our longest standing core area of research and development at Lilly, and it continues to be a great opportunity. We're shifting from just looking at glucose control, which has been the mainstay of diabetes treatment for decades, to actually providing improved outcomes such as increased survival from our medicines. You should expect to see a lot of innovation in the diabetes space, including innovations in how our medicines are delivered.

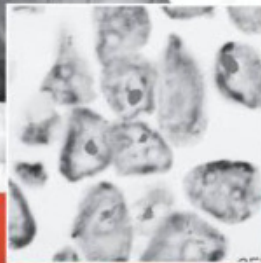
Another area is immunology — we're working on psoriasis, rheumatoid arthritis, lupus, and inflammatory bowel disease. Plus, we're looking for ways to treat chronic pain with non-opioid medicines. I can't predict what areas we'll be working on 10 years from now, but I can tell you our strategy will be the same: We'll go to the areas where we see the intersection of breaking science and unmet medical need.

The Lilly logo, featuring the word "Lilly" in a stylized, cursive script font.

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WE DO."**

JESSICA BAKER

*Lilly Scientist and
Breast Cancer Survivor*



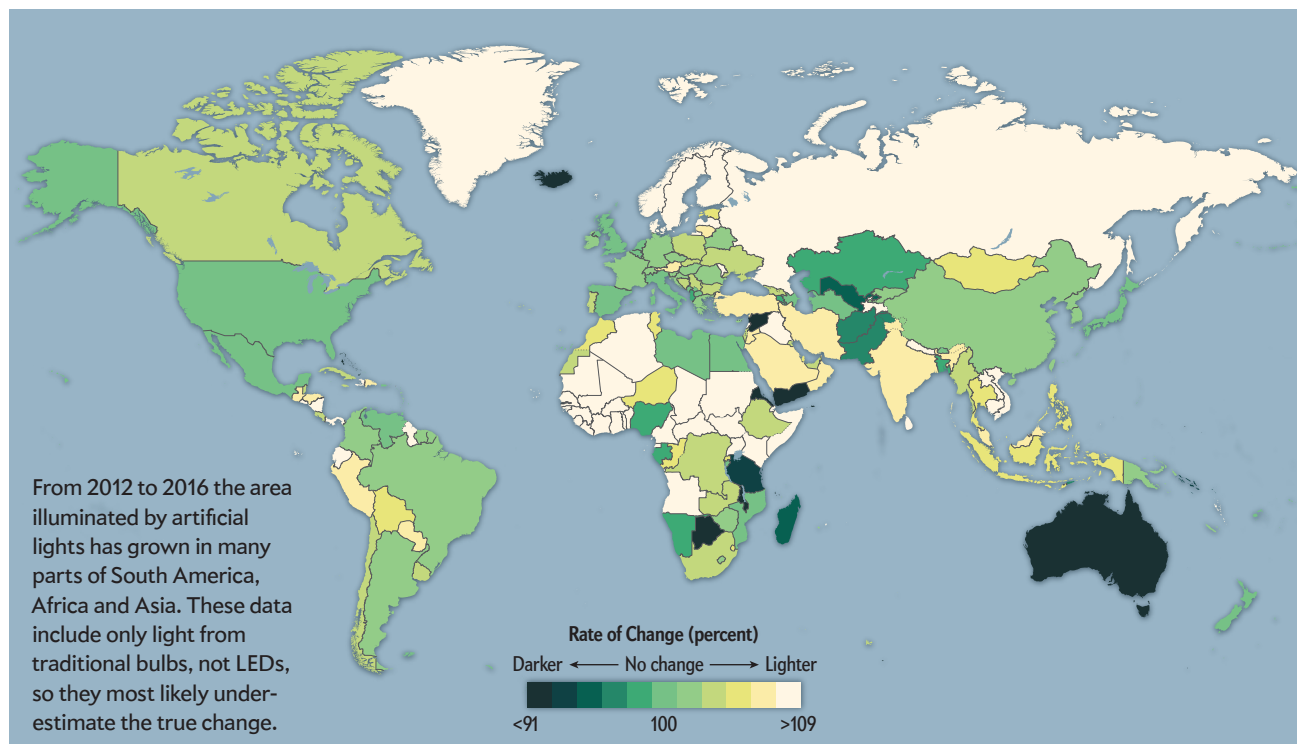
Behind every lab coat is a story.

Jessica's work developing cancer diagnostics at Lilly took on a personal significance when she was diagnosed at age 36 with breast cancer. Medical innovation saved Jessica's life. Now five years in remission, she vows to keep fighting this disease each day as a scientist, advocate, and survivor.

Scientists like Jessica are at the heart of research and drug discovery, dedicating their lives to helping patients around the world. Each scientist has a unique story of why and how they became inspired to dedicate their life to finding medicines to treat some of the world's most devastating diseases.

Learn more about Jessica's story and our research efforts at LillyForBetter.com.

Lilly



measure long wavelengths of light, such as those produced by traditional yellow-and-orange sodium-vapor street lamps. But VIIRS cannot see the short-wavelength blue light produced by white LEDs. This light has been shown to disrupt human sleep cycles and nocturnal animals' behavior.

The team believes the ongoing switch to LEDs caused already bright countries such as Italy, the Netherlands, Spain and the U.S. to register as having stable levels of illumination in the VIIRS data. In contrast, most nations in South America, Africa

and Asia brightened, suggesting increases in the use of traditional lighting. Australia actually appeared to lose lit area—but the researchers say that is because wildfires skewed the data.

"The fact that VIIRS finds an increase [in many countries], despite its blindness in the part of the spectrum that increased more, is very sad," says Fabio Falchi, a researcher at Italy's Light Pollution Science and Technology Institute, who did not participate in the study. In 2016 Falchi, along with Kyba and several other members of his research team, published a

global atlas of artificial lighting that showed one third of the world's population currently lives under skies too bright to see the Milky Way at night.

The data also cast doubt on the idea that the LED lighting revolution will lead to energy cost savings. Between 2012 and 2016 the median nation pumped out 15 percent more long-wavelength light as its GDP increased by 13 percent. And overall, countries' total light production correlated with their GDP. In other words, Kyba says, "we buy as much light as we are willing to spend money on." —Joshua Sokol

SOURCE: "ARTIFICIALLY LIT SURFACE OF EARTH AT NIGHT INCREASING IN RADIANCE AND EXTENT," BY CHRISTOPHER C. M. KYBA ET AL., IN *SCIENCE ADVANCES*, VOL. 3, NO. 11, ARTICLE NO. E701528, NOVEMBER 22, 2017 (map)



Red-tailed weasel lemur

ANIMAL BEHAVIOR

Fruitless Foragers

Lemurs' strange diets could help explain their unique biology

Lemurs are primates, like humans, but they're an odd bunch. Found only on Madagascar, an island off eastern Africa, this group includes some of the only primates known to hibernate—and some of the few that feast primarily on leaves instead of fruits.

By itself, lemurs' preference for greens might not seem all that notable. But Madagascar's birds and bats also consume less fruit than their counterparts in Asia, conti-

nental Africa and the Americas. Because the pattern involves so many types of animals, primatologist Giuseppe Donati of Oxford Brookes University in England suspected there might be something different about the island's fruit itself.

Along with other nutrients, fruits often provide animals with the protein they need for processes from building muscle tissue to moving oxygen through the bloodstream.

STUART WESTMORLAND Getty Images

“It’s still a puzzle why lemurs are strange in many biological ways, and diet is a really important way to look at that.”

**—ANTHROPOLOGIST
CALEY JOHNSON**

By measuring the amount of nitrogen in fruits from 62 tropical areas across the globe, Donati and his team estimated how much protein those fruits offered.

They found that fruits in the Americas, Asia and much of Africa have similar levels of nitrogen, whereas Madagascar’s fruit contains a quarter to a third less. But lemurs still manage to consume the same amount of nitrogen as other primates, suggesting these peculiar animals have found ways to adapt to the lower-quality fruit. “Fruits are not really something that can, in Madagascar, be enough to meet the [lemurs’] nitrogen requirements,” Donati says. And the island’s trees fruit at unpredictable times because of the high frequency of cyclones and low soil fertility, so lemurs might have adopted their leafy diets to compensate. Donati and his colleagues published their results in October 2017 in *Scientific Reports*.

“It’s still a puzzle why lemurs are strange in many biological ways, and diet is a really important way to look at that,” says Arizona State University anthropologist Caley Johnson, who was not involved in the study. Indeed, the results could explain why the few lemur species that do consume a lot of fruit lead a cathemeral way of life—that is, they are active during both the day and night, perhaps because they need the extra feeding time to get enough nutrition. The struggle for nutrients might even explain why some lemurs hibernate. Better to sleep through the winter than risk being unable to find enough to eat.

Lemurs face an existential challenge as one of the most endangered groups of primates on the planet. If conservation efforts are to succeed, the forests these primates rely on for food must be conserved, too.

—Jason G. Goldman



Meteor Crater, Arizona

CHEMISTRY

Diamond in the Rough

X-ray “video” reveals how rare diamonds form

When a meteorite containing graphite slams into the earth, the collision’s heat and pressure can transform this form of carbon into a rare and extremely hard type of diamond. Scientists have long debated exactly how this happens at the atomic level. Now researchers can answer some questions after simulating the precise moment of impact and watching this transformation take place in real time.

In a first-of-its-kind collision chamber at Argonne National Laboratory, physicist Yogendra Gupta of Washington State University and his colleagues mimicked a meteorite impact by firing a lithium fluoride bullet at a graphite disk at 5.1 kilometers per second. Extremely bright x-rays “photographed” the event at 150 billion frames per second.

“In the meteorite world, one always asks if this transition from graphite to diamond happens during compression or as a combination of deformation and [stress release] after the shock,” Gupta says. “We show very nicely that it happens during compression.” Specifically, this rare “hexagonal diamond”—so named for its crystal structure—forms at a pressure of 500,000 atmospheres and on the timescale of billionths of a second. This finding suggests that the impact needed to form this kind of diamond might not be as violent as was previously believed.

Earlier research suggested hexagonal diamond forms only at pressures nearly four times as high—but “that’s been a great controversy,” Gupta says. Other studies showed graphite beginning to transform at lower pressures, but x-ray measurements from these experiments reveal a mixture of different diamond types, so “nobody knows exactly how the transition happens,” he explains. Most prior research examined atomic transformations under gradual compression. In contrast, Gupta and his colleagues’ experiments show hexagonal diamond forming directly from graphite during a sudden shock, in perfect alignment with the impact direction. The study was published last October in *Science Advances*.

“What is most exciting about this work is the way in which the researchers determined the precise locations of the atoms while en route from one crystal structure to the other,” says Lorin Benedict, a physicist at Lawrence Livermore National Laboratory, who was not involved in the work.

The diamond held its form after the pressure was dialed down—but Gupta wants to know whether it will remain stable when the stress is reduced to zero. Such experiments might lead to a novel way to create diamonds for industrial use.

—Rachel Berkowitz

ECOLOGY

Salmon Sex Moves Mountains

Spawning drives riverbed erosion over millions of years

Fish sex might not seem very consequential, but countless couplings over the course of millennia can leave a mark on the landscape. In a recent study, researchers modeled how spawning affects rivers in the Pacific Northwest and concluded that salmon sex actually helped to carve the region's mountainsides.

Salmon return from the sea to the rivers and streams of their birth to reproduce. Once a female finds a spot with the right size rocks or gravel, she digs a pit for her eggs.



Spawning pink salmon

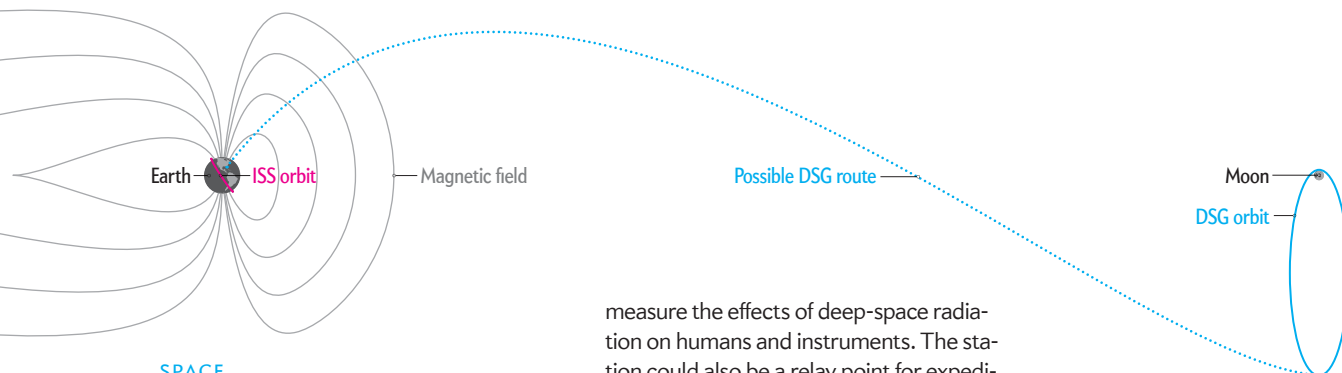
After the male fertilizes them, the female digs another hole upstream and covers her brood with the sediment from it. Her excavation erodes the streambed by making it easier for sediment and gravel to move downstream, says study co-author Alexander K. Fremier, an aquatic ecologist at Washington State University.

Fremier and his colleagues collected data on salmon-caused erosion rates in an experimental stream and extrapolated their findings to real rivers over millions of years. Spawning may have caused some riverbeds to lower by 30 percent more than if no spawning had taken place, they reported

in the study, which was published online last September in the journal *Geomorphology*.

David R. Montgomery, a professor of geomorphology at the University of Washington, who was not involved in the research, calls the study a fascinating “illustration of the degree to which biological activity and things we normally think of as physical processes can be linked.” Montgomery’s own research indicates that mountain uplift may have fueled salmon diversification, specialization and speciation. The new work suggests that salmon spawning could further enhance these processes by changing erosion rates and river slopes. Montgomery believes any such effect would be minimal in comparison to that caused by uplift but adds that Fremier and his colleagues have “opened the door to asking the question” about the phenomenon and all its cascading consequences. —Doug Main

ASHLEY MORGAN/Getty Images



SPACE

Moon Shot

NASA is developing a far-out plan for a lunar space station

The next chapter in cosmic exploration is starting to take shape: NASA engineers have proposed a space station that—if Congress approves its funding—would begin orbiting the moon in about a decade. A primary goal is to develop the infrastructure and experience to one day land humans on Mars.

The Deep Space Gateway (DSG) project would likely be a collaboration among the U.S., Russia and other international partners. It would sit in a lunar orbit about 240,000 miles from Earth—1,000 times farther than the International Space Station (ISS). This would put it outside Earth’s protective magnetic field, letting scientists

measure the effects of deep-space radiation on humans and instruments. The station could also be a relay point for expeditions to the moon’s surface. Plans for lunar landers—bearing humans or robots, or both—are still under discussion. NASA officials say astronauts and construction materials could be ferried to lunar orbit in four Orion rocket launches sometime after 2019.

But the proposal has its critics. After the *Columbia* space shuttle disaster in 2003, NASA vowed to launch humans separately from cargo—a principle the DSG plan appears to violate. Some space policy experts warn that lunar operations are expensive and could be more of a distraction from Mars than a step toward it. Others question whether the month-long stays planned for the new station would teach NASA enough about how the human body responds to deep space, given that the journey to Mars requires at least six months. One lunar engineer has expressed concern about intermittent and unpredict-

able solar storms. Such events might subject astronauts to dangerous radiation levels in the absence of a shield, such as a thick layer of water, which would need to be built into the space station’s design.

Despite these reservations, many experts agree the moon could be a crucial training and proving ground—not just for astronauts but also for the Earth-based operations and equipment to support human spaceflight. “In my mind, it is clear you have to do the lunar exploration first,” says David Kring, a scientist at the Lunar and Planetary Institute in Houston, who has worked extensively on moon mission planning. Humans have not landed on the moon since the 1970s. The current generation of spaceflight engineers needs to learn to work on an extraterrestrial surface, Kring says, “and the best place to do that is three days away.” —Katie Peek

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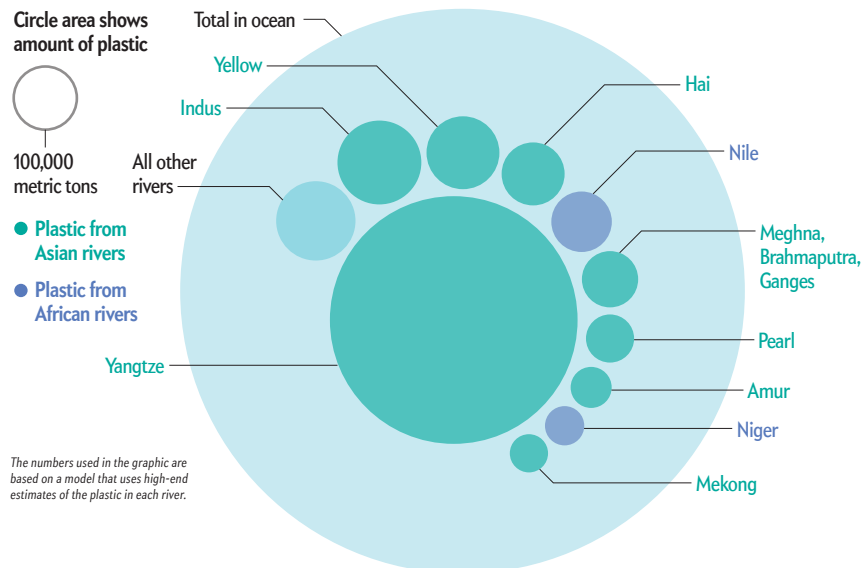
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Rivers of Plastic

A significant amount of the waste in oceans comes from just 10 rivers

Our seas are choking on plastic. A staggering eight million metric tons wind up in oceans every year, and unraveling exactly how it gets there is critical. A recent study estimates that more than a quarter

of all that waste could be pouring in from just 10 rivers, eight of them in Asia.

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BIOPHYSICS

Porpoise-Driven Life

The marine mammals have their own natural sonar

The best military sonar technology pales in comparison with the echolocation porpoises use to track prey, predators and obstacles. The marine mammals can find objects a few centimeters wide from 100 meters away—akin to spotting a walnut from across a football field—by releasing clicks from their blowholes. Sonar-equipped ships, in contrast, must emit sound waves from multiple sources spread out over at least a few meters. A recent study suggests porpoises’ ultraefficient echolocation is made possible by adjustable structures in their heads—a finding that may help humans improve our own sonar technology.



Yangtze finless porpoise

Sonar works by bouncing sound waves off objects and detecting the signals’ return time. Normally if the source of a sonar pulse is smaller than the wavelength of the sound, it releases sound signals in all directions, like light scattering from a disco ball. To send a targeted beam in a specific direction, the source must be much larger than the wavelength. But porpoises manage to evade this requirement.

To find out how, scientists used CT

SOURCE: “EXPORT OF PLASTIC DEBRIS BY RIVERS INTO THE SEA,” BY CHRISTIAN SCHMIDT ET AL., IN ENVIRONMENTAL SCIENCE & TECHNOLOGY, VOL. 51, NO. 21, NOVEMBER 7, 2017

GETTY IMAGES

Graphic by Amanda Montañez

ground in the fight against sea pollution, explains Christian Schmidt, a hydrogeologist at the Helmholtz Center for Environmental Research in Leipzig, Germany.

Schmidt and his colleagues dug up published data on the plastic concentration in 57 rivers of various sizes around the world. These measurements included bottles and bags, as well as microscopic fibers and beads. The researchers multiplied these concentrations by the rivers' water discharge to calculate the total weight of plastic flowing into the sea. They then fed these data into a model that compared them with the estimated weight of plastic litter generated per person per day along each river.

The results, published last November in *Environmental Science & Technology*, show that rivers collectively dump anywhere from 0.47 million to 2.75 million metric tons of plastic into the seas every year, depending on the data used in the models. The 10 rivers that carry 93 percent of that trash are the Yangtze, Yellow, Hai, Pearl, Amur, Mekong, Indus and Ganges Delta in Asia, and the Niger and Nile in Africa. The Yangtze alone dumps up to an estimated 1.5 million metric tons of plastic waste into the Yellow Sea.

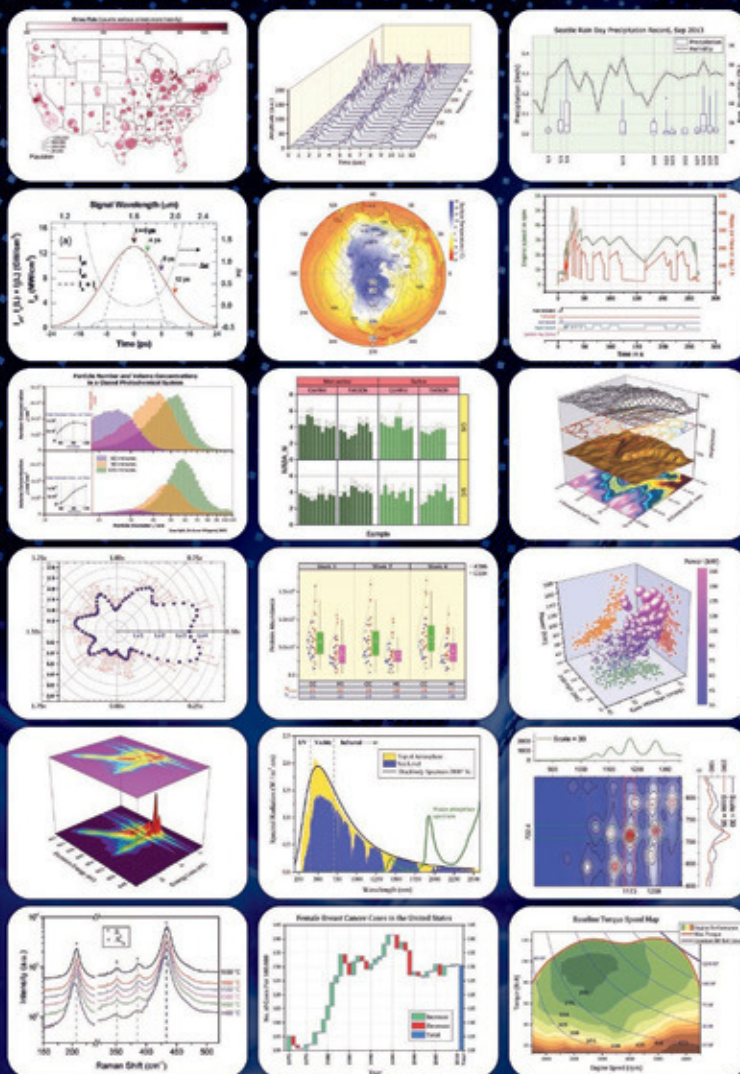
Better waste collection and management practices in the most polluted regions would help stem the tide, Schmidt says, but raising public awareness is also crucial. —Prachi Patel

scans to study the heads of finless porpoises (*Neophocaena phocaenoides*). They learned the creatures' foreheads contain complicated structures involving air sacs, soft tissues and skull bones. These components make up layers that let sound pass through at different velocities, enabling the animals to control their beams' focus. "If we can understand these structures, then we can redesign our sonar systems and put them into [smaller] boats," says Wenwu Cao, a physicist at Pennsylvania State University and co-author of the study, published last December in *Physical Review Applied*.

The work suggests that porpoises share some tricks with another mammal famous for echolocation: bats. "I am intrigued that there could be a way for the porpoises to change their emission pattern by compressing the forehead complex," says Rolf Müller, a professor of mechanical engineering at Virginia Tech, who has studied bat sonar but was not involved in the porpoise study. Next to human technology, it seems bats and porpoises really are a few flaps or laps ahead. —Clara Moskowitz

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SUSTAINABILITY

Greener Skies

A new airplane design aims for greater fuel efficiency and lower emissions

Airplane emissions are a big problem for the climate—and steadily rising. If the aviation sector were a country, it would rank seventh worldwide in carbon pollution. Experts predict that aircraft emissions, on their current trajectory, will triple by 2050 as demand for flights increases. To prevent this dire scenario, a team of scientists at the Massachusetts Institute of Technology, along with government and industry collaborators, is attempting to fundamentally redesign airplanes.

Their concept, dubbed the “double-bubble” D8, could significantly reduce aviation’s carbon footprint and improve fuel efficiency if validated in full-scale tests. It entails major changes to the standard 180-passenger Boeing 737 and Airbus A320 aircraft—for example, the fuselage has a wider, more oval shape than a conventional jet. “It’s like two bubbles [joined] side by side,” explains Alejandra Uranga, an assistant professor of aerospace and mechanical engineering now at the University of Southern California. This modification lets the fuselage itself generate some lift, says Uranga, who is a co-principal investigator for the project, alongside Edward Greitzer of M.I.T. The altered body shape allows the wings and tail to be smaller and lighter, and the aircraft’s nose is also more aerodynamic.

The most significant change, though, is the engine position. Air slows down as it flows over the top of a conventional plane, thereby creating drag and making the craft less efficient. But the D8 design moves the jet’s engines from their usual spot underneath the wings to atop the plane’s body, by the tail—where they suck in and reaccelerate the slow layer of air, greatly reducing drag.

These alterations would make the aircraft use 37 percent less fuel than a typical passenger jet, Uranga says. The project’s chief engineer Mark Drela, Uranga, Greitzer and their collaborators at M.I.T., NASA, Aurora Flight Sciences and Pratt & Whitney have already built and tested an 11th-scale model of the aircraft in a NASA wind tunnel. Combining the new design



1



2

A scale model of the “double-bubble” D8 aircraft (1) is shown. The design’s wider fuselage and repositioned engines reduce drag and weight, making it more efficient (2).

with future technological advances could further reduce fuel use and ultimately add up to 66 percent in fuel savings in two decades, Uranga says.

Other experts note that the D8’s devel-

opers must still overcome economic obstacles while ensuring that the engines are robust enough to handle the new configuration. Still, “it’s a very compelling idea and design,” says Brian J. German, an aerospace engineer at the Georgia Institute of Technology, who was not involved in the work. Aurora is now exploring the development of a half-scale prototype plane. If the effort succeeds, travelers may fly in one of these jets as soon as 2035.

—Annie Sneed

COURTESY OF DAVID C. BOWMAN AND NASA’S LANGLEY RESEARCH CENTER (1); COURTESY OF NASA, M.I.T. AND AURORA FLIGHT SCIENCES (2)

PROMOTION

The Agenda Setters

Bringing Science to Life



Vaccines & Immunotherapy: The Complete Picture

Gaylord Center | National Harbor, MD | November 9th, 2017

Continuing a partnership series with **Immunomic Therapeutics, Inc.**, **Scientific American Custom Media** hosted a unique event last November exploring the role vaccines will play in the ever-expanding immunotherapy arsenal. Co-located with the annual meeting of the Society for Immunotherapy in Cancer (SITC) at the Gaylord Center in National Harbor, MD, this salon discussion featured key opinion leaders from the clinical, academic, patient advocacy and commercial worlds.

Conversationalists included **Drew Pardoll** of Johns Hopkins University, **Andrew Allen** of Gritstone Oncology, **Paula Rothenberg** of Hope Connections for Cancer Support, **Bill Hearl** of Immunomic Therapeutics, **Gad Berdugo** of Epivax and **Matt Mulvey** of Benevir. Also making an appearance and adding some timely commentary was **Lisa Butterfield**, president of SITC.

A lively discussion and audience Q&A, moderated by Scientific American publisher, **Jeremy Abbate**, brought together many perspectives on the future technologies driving immunotherapy and how vaccines might represent a platform for the new paradigm in conceptualizing cancer.

TECH

Wearable Data

Magnetic clothing could store pass codes and unlock doors

The classic nightmare of suddenly realizing you're naked in public could soon get a futuristic twist: it might involve the horror of losing not just your modesty but also your pass codes. Scientists recently created magnetic garments that they say can store data, automatically unlock doors or control a nearby smartphone with gestures.

The concept of interactive "smart clothing" has drawn attention in the past couple of years. For example, Google and Levi's created a touch-sensitive denim jacket that can operate a smartphone. This and other smart garments are made with conductive thread and usually require an attached electronic device.

To eliminate the need for such peripheral

gear, researchers at the University of Washington recently took advantage of what they say is a previously untapped property of conductive thread: its ability to be magnetized. Using magnetic instead of electric properties of the thread "may seem like a small difference, but it's what makes this work interesting and exciting," says Chris Harrison, a computer scientist at Carnegie Mellon University, who was not part of the research. The new technique allowed the researchers to do something they say is unique among wearables: turn them into storage devices.

The Washington team magnetized a patch of fabric embroidered with conductive thread, giving different parts of the

cloth a north or south orientation that corresponded to binary 1's or 0's. This step allowed the researchers to store up to 33 million different combinations—such as pass codes for doors—on a shirt cuff. They also created magnetic gloves that could control a nearby smartphone with gestures. The team described its findings last October at a meeting of the Association for Computing Machinery.

The garments still stored data after washing, drying and ironing, but they could not escape time's eraser; after about a week, the threads' magnetic fields had weakened by around 30 percent. The researchers suggest that using custom-made thread designed to hold stronger magnetic fields might work longer. But for now the clothes may be best suited for storing temporary codes, such as those found on hotel key cards or clothing tags in stores.

Harrison says that it is "very unlikely you're ever going to achieve a comparable density [to magnetic hard drives]" with data-storing fabric, however.

—Yasemin Saplakoglu



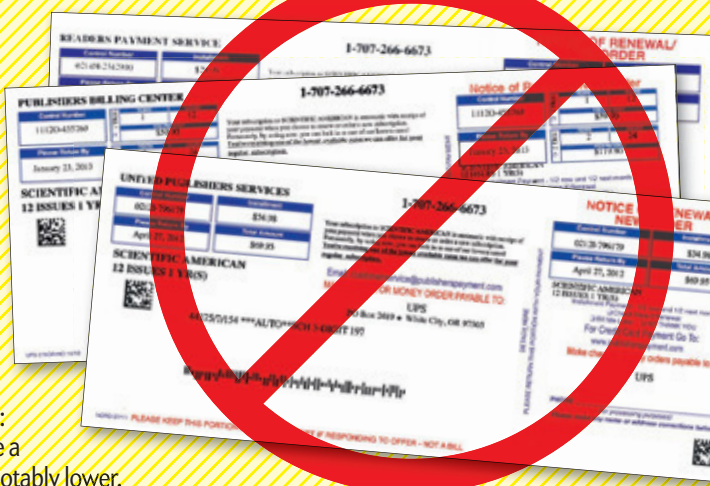
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IN THE NEWS

Quick Hits

PACIFIC OCEAN

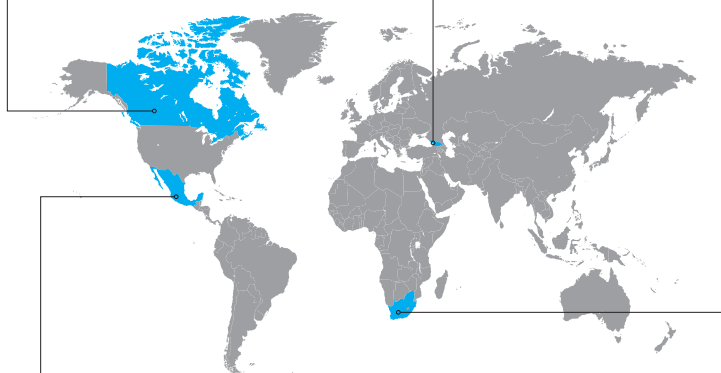
Researchers from the Sky Ocean Rescue campaign found plastic traces in the stomachs of crustaceans that dwell in the darkest ocean depths, including the 36,000-foot-deep Mariana Trench. Scientists are concerned that plastic pollution may now have penetrated every marine ecosystem on the planet.

CANADA

Edmonton International Airport tested a drone with flapping wings called the Robird, which is intended to scare real birds away from aircraft. The prototype was modeled on a peregrine falcon; its developers are now working on a mechanical bald eagle.

GEORGIA

Scientists excavated eight ancient jars, the oldest one dating back to 5980 B.C., from two Georgian villages. The vessels bore chemical footprints of grape fermentation, making them the earliest known evidence of wine making.



SOUTH AFRICA

A project called the International Barcode of Life presented a portable DNA-identifying technology that could help South African customs officials rapidly classify animal bones. The tool's creators hope it will help fight trafficking of endangered or invasive animals.

MEXICO

Scientists installed a network of seismometers and GPS stations on the seafloor off the state of Guerrero. A contraption called a wave glider floats above the seismometers and collects data to predict whether stresses on the ocean floor are building toward major earthquakes.

ANTARCTICA

Biologists calculated the weight of leopard seals by taking aerial photographs of them with drones. The conventional method—individually capturing and weighing the seals—takes hours and is disruptive to the animals.

For more details, visit www.ScientificAmerican.com/feb2018/advances

—Yasemin Saplakoglu

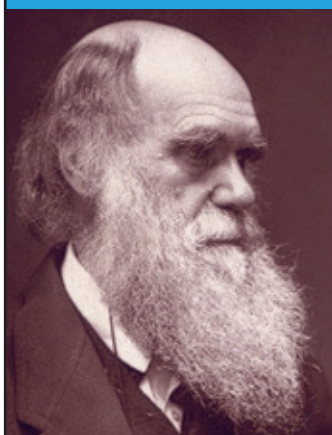
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—Charles Darwin

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Claudia Wallis is an award-winning science writer and former managing editor of *Scientific American Mind*.



Why Fake Operations Are a Good Thing

They can reveal whether popular surgeries are actually effective

By Claudia Wallis

Two weeks after my husband had a couple of stents installed in his coronary arteries, he awoke to this headline in the *New York Times*: “‘Unbelievable’: Heart Stents Fail to Ease Chest Pain.” He was incredulous. For weeks before his surgery, he had felt stabbing pains in his chest any time he exerted himself. Now he felt fantastic and was back to playing his beloved Ultimate Frisbee.

The headline reflected the results of a British study, published online last November in the *Lancet*, that used what is probably the best methodology for assessing a surgical procedure: sham surgery. In this case, 200 patients with a blocked artery were randomly assigned to get either a real stent operation or a fake one. In the real version, a surgeon snaked a balloon-tipped catheter through an artery in the groin or arm up to the blockage, widened the vessel by inflating the balloon, and then kept it open with a tubelike stent made of wire mesh. In the sham procedure, a catheter was directed to the blockage, but the surgeon only pretended to do the rest. The astonishing finding: there was no difference in how the patients felt six weeks after surgery. Both groups re-

ported less pain, and both performed better on treadmill tests.

Stent operations, or angioplasties, are wildly popular. At least half a million are done annually around the world. There is little question they are great for people in the throes of a heart attack but serious debate over their merits for other patients. Multiple studies have shown that they do not lower the risk of heart attacks or death. The main justification has been to relieve symptoms such as chest pain, known as stable angina, and shortness of breath. The British study has now undercut that idea. Giving drugs to control cardiovascular disease, as was done for all 200 patients in the study, along with lifestyle changes, appears to be the way to go for most people.

How did an operation that now seems to have a rather limited application become such a blockbuster? You might ask the same question about many other procedures. Take arthroscopic knee surgery, the number-one most common orthopedic operation. More than two million are done annually to tidy up ragged cartilage in people with arthritis and degenerative wear and tear in their knees, including a torn meniscus. Yet sham surgery studies and other research have shown it offers no advantages for the vast majority of such patients. They would do just as well with physical therapy, weight loss and exercise.

Consider this: before a new drug is approved for marketing, researchers must show that it is more effective than a sugar pill. Not so for a new operation. And yet surgeries have a much bigger placebo effect than drugs. To quantify the difference, a 2013 meta-analysis looked at placebo effects in 79 studies of migraine prevention: sugar pills reduced headache frequency for 22 percent of patients, fake acupuncture helped 38 percent, and sham surgery was a hit for a remarkable 58 percent. “There’s a big placebo effect with any procedure,” says cardiologist Rita Redberg of the University of California, San Francisco.

And yet sham surgery studies are rarely done, especially in the U.S., where ethics boards resist subjecting patients to incisions, anesthesia and other risks without delivering an actual treatment. Redberg, who has written about the value of these studies, takes the opposite view: “I think it’s unethical not to do them.” Otherwise you may be exposing millions of people to the risks and the financial costs of surgery for a placebo effect that will not likely last.

Sham-controlled studies have spared us some useless operations. Vertebroplasty—injecting bone cement to mend a fractured vertebra—was gaining credence in the early 2000s until a 2009 sham study showed it was no better than a placebo. Since then, its popularity has dropped by about 50 percent, according to David S. Jevsevar, chair of orthopedics at the Geisel School of Medicine at Dartmouth. His research also shows a 28 percent decline in people with arthritis getting arthroscopic meniscus surgery.

But changing doctors’ behavior is tough. They tend to think that “this is what we’ve been trained to do and we get good results, so we should keep on doing it,” Jevsevar observes.

Stent surgery will most likely remain unreasonably popular for a long while. My advice if someone close to you is about to get it is to ask questions, lots of questions, beginning with: Wouldn’t drugs, diet and exercise do the trick? ■



David Pogue is the anchor columnist for Yahoo Tech and host of several NOVA miniseries on PBS.

The Robotic Artist Problem

When AI creates compelling art, the meaning of creativity gets blurred

By David Pogue

You've probably heard that automation is becoming commonplace in more fields of human endeavor. Or, in headline-speak: "Are Robots Coming for Your Job?"

You may also have heard that the last bastions of human exclusivity will probably be creativity and artistic judgment. Robots will be washing our windows long before they start creating masterpieces. Right?

Not necessarily. In reporting a story for *CBS Sunday Morning*, for example, I recently visited Rutgers University's Art and Artificial Intelligence Laboratory, where Ahmed Elgammal's team has created artificial-intelligence software that generates beautiful, original paintings.

Software is doing well at composing music, too. At Amper Music (www.ampermusic.com), you can specify what kind of music you want based on mood, instrumentation, tempo and duration. You click "Render," and boom! There's your original piece, not only composed but also "performed" and "mixed" by AI software.

Amper's software doesn't write melodies. It does, however, produce impressive background tracks—that is, mood music. This company is going after stock-music houses, companies that sell ready-to-download music for reality TV shows, Web videos, student movies, and so on.

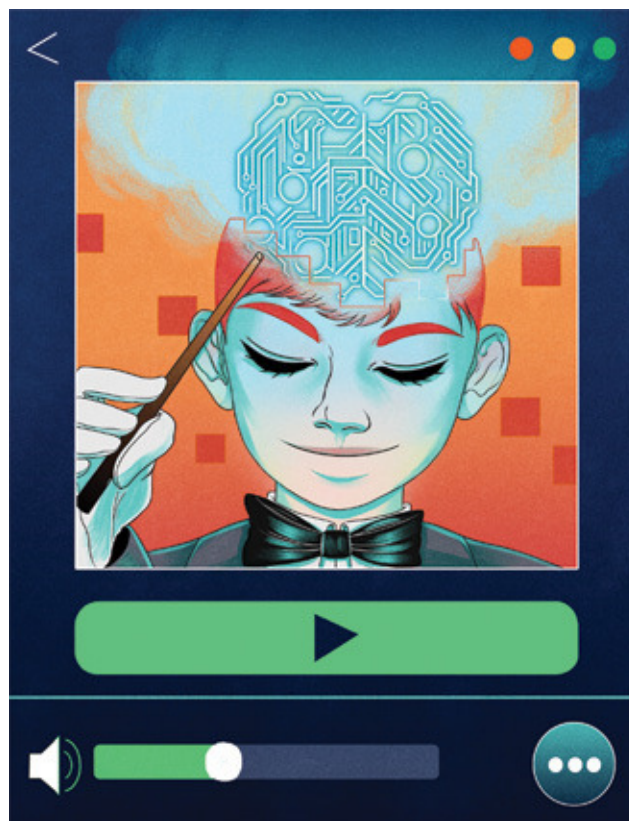
I found these examples of robotically generated art and music to be polished and appealing. But something kept nagging at me: What happens in a world where effort and scarcity are no longer part of the definition of art?

A mass-produced print of the *Mona Lisa* is worth less than the actual Leonardo painting. Why? Scarcity—there's only one of the original. But Amper churns out another professional-quality original piece of music every time you click "Render." Elgammal's AI painter can spew out another 1,000 original works of art with every tap of the enter key. It puts us in a weird hybrid world where works of art are unique—every painting is different—but require almost zero human effort to produce. Should anyone pay for these things? And if an artist puts AI masterpieces up for sale, what should the price be?

That's not just a thought experiment, either. Soon the question "What's the value of AI artwork and music?" will start impacting flesh-and-blood consumers. It has already, in fact.

Last year the music-streaming service Spotify lured AI researcher François Pachet away from Sony, where he'd been working on AI software that writes music.

Earlier, reporters at the online trade publication Music Business Worldwide discovered something fishy about many of Spoti-



fy's playlists: according to the report, songs within them appeared to be credited to nonexistent composers and bands. These playlists have names like Peaceful Piano and Ambient Chill—exactly the kind of atmospheric, melodyless music AI software is good at.

Is Spotify using software to compose music to avoid paying royalties to human musicians? The *New York Times* reported that the tracks with pseudonyms have been played 500 million times, which would ordinarily have cost Spotify \$3 million in payments.

But Spotify says Pachet was hired to create tools for human composers. And it has flatly denied that the tracks in question were created by "fake" artists to avoid royalties: while posted under the names of pseudonyms, they were written by actual people receiving actual money for work that they own. (It's still possible Spotify is paying *lower* royalties to these mysterious music producers.) But the broader issue remains. Why *couldn't* Spotify, or any music service, start using AI to generate free music to save itself money? Automation is already on track to displace millions of human taxi drivers, truck drivers and fast-food workers. Why should artists and musicians be exempt from the same economics?

Should there be anything in place—a union, a regulation—to stop that from happening? Or will we always value human-produced art and music more than machine-made stuff? Once we've answered those questions, we can tackle the really big one: When an AI-composed song wins the Grammy, who gets the trophy? ■

SCIENTIFIC AMERICAN ONLINE

READ A REVIEW OF MUSIC COMPOSED BY AI:
scientificamerican.com/feb2018/pogue

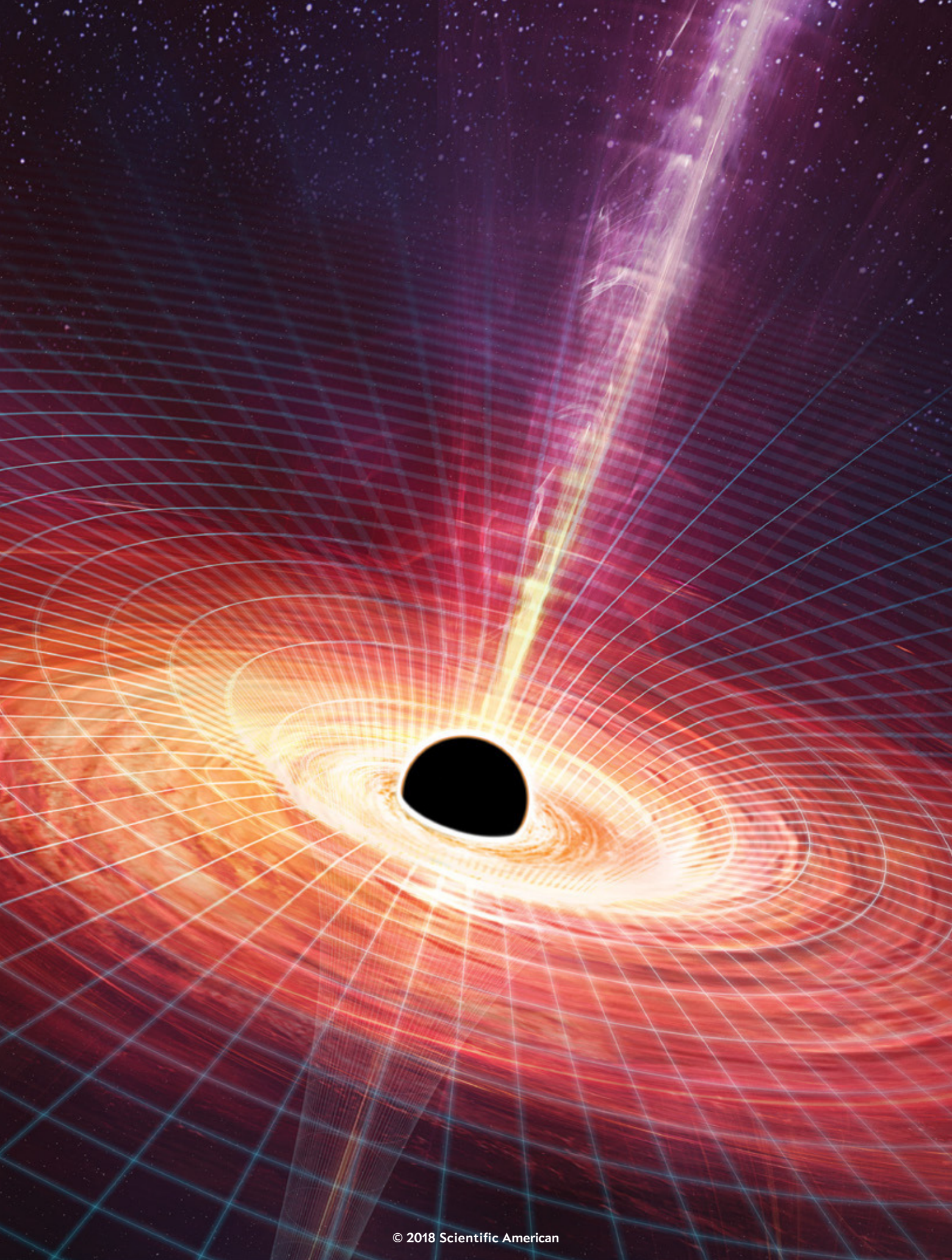
ASTROPHYSICS

THE FIRST MONSTER BLACK HOLES

Astronomers are puzzled about how the oldest supermassive black holes could have grown so big so early in cosmic history

By Priyamvada Natarajan

Illustration by Mark Ross



Priyamvada Natarajan is a theoretical astrophysicist at Yale University whose research focuses on cosmology, gravitational lensing and black hole physics.



IMAGINE THE UNIVERSE IN ITS INFANCY. MOST SCIENTISTS THINK SPACE AND TIME originated with the big bang. From that hot and dense start the cosmos expanded and cooled, but it took a while for stars and galaxies to start dotting the sky. It was not until about 380,000 years after the big bang that atoms could hold together and fill the universe with mostly hydrogen gas. When the cosmos was a few hundred million years old, this gas coalesced into the earliest stars, which formed in clusters that clumped together into galaxies, the oldest of which appears 400 million years after the universe was born. To their surprise, scientists have found that another class of astronomical objects begins to appear at this point, too: quasars.

IN BRIEF

In the very distant, ancient universe, astronomers can see quasars—extremely bright objects powered by enormous black holes. Yet it is unclear how black holes this large could have formed so quickly after the big bang.

To solve the mystery, scientists proposed a novel mechanism for black hole formation. Rather than being born in the deaths of massive stars, the seeds of the most ancient supermassive black holes might have collapsed directly from gas clouds.

Astronomers may be able to find evidence for direct-collapse black holes using the James Webb Space Telescope, due to launch in 2019, which should see farther back in space and time than any instrument before it.

Quasars are extremely bright objects powered by gas falling onto supermassive black holes. They are some of the most luminous things in the universe, visible out to the farthest reaches of space. The most distant quasars are also the most ancient, and the oldest among them pose a mystery.

To be visible at such incredible distances, these quasars must be fueled by black holes containing about a billion times the mass of the sun. Yet conventional theories of black hole formation and growth suggest that a black hole big enough to power these quasars could not have formed in less than a billion years. In 2001, however, with the Sloan Digital Sky Survey, astronomers began finding quasars that dated back earlier. The oldest and most distant quasar known, which was reported last December, existed just 690 million years after the big bang. In other words, it does not seem that there had been enough time in the history of the universe for quasars like this one to form.

Many astronomers think that the first black holes—seed black holes—are the remnants of the first stars, corpses left behind after the stars exploded into supernovae. Yet these stellar remnants should contain no more than a few hundred solar masses. It is difficult to imagine a scenario in which the black holes powering the first quasars grew from seeds this small.

To solve this quandary, a decade ago some colleagues and I proposed a way that seed black holes massive enough to explain the first quasars could have formed without the birth and death of stars. Instead these black hole seeds would have formed directly from gas. We call them direct-collapse black holes (DCBHs). In the right environments, direct-collapse black holes could have been born at 10^4 or 10^5 solar masses within a few hun-

dred million years after the big bang. With this head start, they could have easily grown to 10^9 or 10^{10} solar masses, thereby producing the ancient quasars that have puzzled astronomers for nearly two decades.

The question is whether this scenario actually happened. Luckily, when the James Webb Space Telescope (JWST) launches in 2019, we should be able to find out.

THE FIRST SEEDS

BLACK HOLES ARE ENIGMATIC astronomical objects, areas where the gravity is so immense that it has warped spacetime so that not even light can escape. It was not until the detection of quasars, which allow astronomers to see the light emitted by matter falling into black holes, that we had evidence that they were real objects and not just mathematical curiosities predicted by Einstein's general theory of relativity.

Most black holes are thought to form when very massive stars—those with more than about 10 times the mass of sun—exhaust their nuclear fuel and begin to cool and therefore contract. Eventually gravity wins, and the star collapses, igniting a cataclysmic supernova explosion and leaving behind a black hole. Astronomers have traditionally assumed that most of the black holes powering the first quasars formed this way, too. They could have been born from the demise of the universe's first stars (Population III stars), which we think formed when primordial gas cooled and fragmented about 200 million years after the big bang. Population III stars were probably more massive than stars born in the later universe, which means they could have left behind black holes as hefty as several hundred solar masses. These stars also probably formed in dense clusters, so it is likely that the black holes created on

their deaths would have merged, giving rise to black holes of several thousand solar masses. Even black holes this large, however, are far smaller than the masses needed to power the ancient quasars.

Theories also suggest that so-called primordial black holes could have arisen even earlier in cosmic history, when spacetime may have been expanding exponentially in a process called inflation. Primordial black holes could have coalesced from tiny fluctuations in the density of the universe and then grown as the universe expanded. Yet these seeds would weigh only between 10 and 100 solar masses, presenting the same problem as Population III remnants.

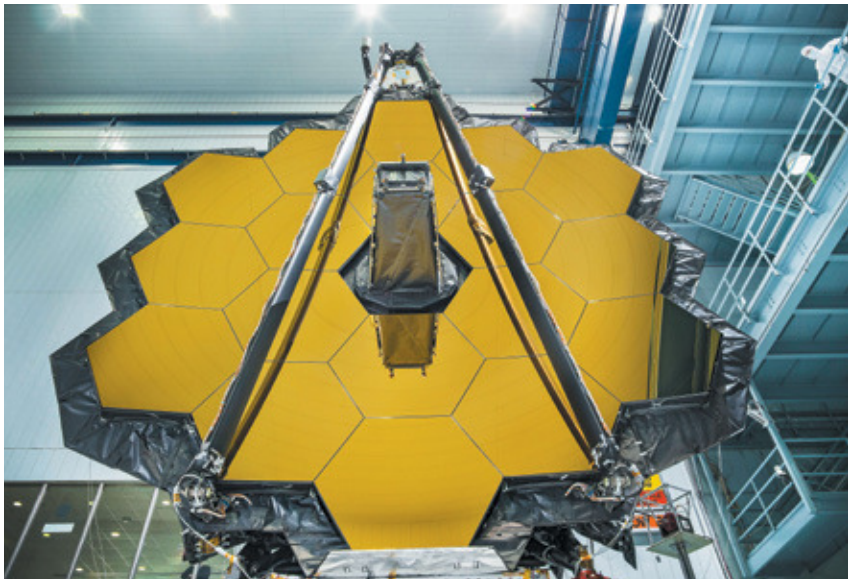
As an explanation for the first quasars, each of these pathways for the formation of black hole seeds has the same problem: the seeds would have to grow extraordinarily quickly within the first billion years of cosmic history to create the earliest quasars. And what we know about the growth of black holes tells us that this scenario is highly unlikely.

FEEDING A BLACK HOLE

OUR CURRENT UNDERSTANDING of physics suggests that there is an optimal feeding rate, known as the Eddington rate, at which black holes gain mass most efficiently. A black hole feeding at the Eddington rate would grow exponentially, doubling in mass every 10^7 years or so. To grow to 10^9 solar masses, a black hole seed of 10 solar masses would have to gobble stars and gas unimpeded at the Eddington rate for a billion years. It is hard to explain how an entire population of black holes could continuously feed so efficiently.

In effect, if the first quasars grew from Population III black hole seeds, they would have had to eat faster than the Eddington rate. Surpassing that rate is theoretically possible under special circumstances in dense, gas-rich environments, and these conditions may have been available in the early universe, but they would not have been common, and they would have been short-lived. Furthermore, exceptionally fast growth can actually cause “choking,” where the radiation emitted during these super-Eddington episodes could disrupt and even stop the flow of mass onto the black hole, halting its growth. Given these restrictions, it seems that extreme feasting could account for a few freak quasars, but it cannot explain the existence of the entire detected population unless our current understanding of the Eddington rate and black hole feeding process is wrong.

Thus, we must wonder whether the first black hole seeds could have formed through other channels. Building on the work of several other research groups, my collaborator Giuseppe Lodato and I published a set of papers in 2006 and 2007 in which we proposed a novel mechanism that could have produced more mas-



sive black hole seeds from the get-go. We started with large, pristine gas disks that might otherwise have cooled and fragmented to give rise to stars and become galaxies. We showed that it is possible for these disks to circumvent this conventional process and instead collapse into dense clumps that form seed black holes weighing 10^4 to 10^6 solar masses. This outcome can occur if something interferes with the normal cooling process that leads to star formation and instead drives the entire disk to become unstable, rapidly funneling matter to the center, much like water flowing down a bathtub drain when you pull the plug.

Disks cool down more efficiently if their gas includes some molecular hydrogen—two hydrogen atoms bonded together—rather than atomic hydrogen, which consists of only one atom. But if radiation from stars in a neighboring galaxy strikes the disk, it can destroy molecular hydrogen and turn it into atomic hydrogen, which suppresses cooling, keeping the gas too hot to form stars. Without stars, this massive irradiated disk could become dynamically unstable, and matter would quickly drain into its center, rapidly driving the production of a massive, direct-collapse black hole. Because this scenario depends on the presence of nearby stars, we expect DCBHs to typically form in satellite galaxies that orbit around larger parent galaxies where Population III stars have already formed.

Simulations of gas flows on large scales, as well as the physics of small-scale processes, support this model for DCBH formation. Thus, the idea of very large initial seeds appears feasible in the early universe. And starting with seeds in this range alleviates the timing problem for the production of the supermassive black holes that power the brightest, most distant quasars.

LOOKING FOR PROOF

BUT JUST BECAUSE DCBH SEEDS are feasible does not mean they actually exist. To find out, we must search for ob-

DUE TO LAUNCH in 2019, the James Webb Space Telescope will be powerful enough to find evidence for direct-collapse black holes, if they exist.

CONVENTIONAL SCENARIO

When the first (Population III) stars exhausted their nuclear fuel, they collapsed in supernova explosions, leaving behind black holes. By rapidly eating nearby stars and gas, they then grew into much larger black holes.



Big bang

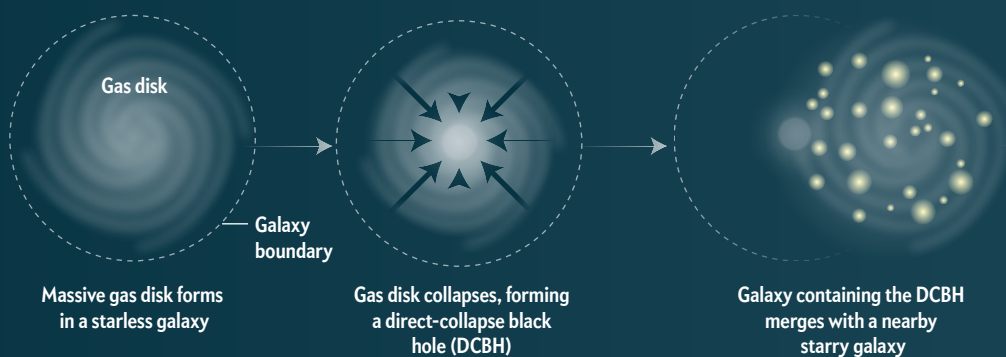
~180 million years

~270 million years

~370 million years

DIRECT-COLLAPSE SCENARIO

If star formation stalled in a budding galaxy, the entire gas disk could have collapsed into a black hole. If this black hole then collided with a nearby galaxy, it could have grown quickly by feeding on that galaxy's stars and gas, producing an "obese black hole galaxy" that telescopes could spot.



servational evidence. These objects would appear as bright, miniature quasars shining through the early universe. They should be detectable during a special phase when the seed merges with the parent galaxy—and this process should be common, given that DCBHs probably form in satellites orbiting larger galaxies. A merger would give the black hole seed a copious new source of gas to eat, so the black hole should start growing rapidly. In fact, it would briefly turn into a special kind of quasar that outshines all the stars in the galaxy.

These black holes will not only be brighter than their surrounding stars, they will also be heavier—a reversal of the usual order of things. In general, the stars in a galaxy outweigh the central black holes by about a factor of 1,000. After the galaxy hosting the DCBH merges with its parent galaxy, however, the mass of the growing black hole will briefly exceed that of the stars. Such an object, called an obese black hole galaxy (OBG), should have a very special spectral signature, particularly in the infrared wavelengths between one and 30 microns where the JWST's Mid-Infrared Instrument (MIRI) and Near-Infrared Camera (NIRCam) cameras will operate. This telescope will be the most powerful tool astronomers have ever had for peering into the earliest stages of cosmic history. If the telescope detects these obese black hole galaxies, it will provide strong evidence for our DCBH theory. Tradi-

tional black hole seeds, on the other hand, which derive from dead stars, are likely to be too faint for the JWST or other telescopes to see.

It is also possible that we might find other evidence for our theory. In the rare case that the parent galaxy that merges with the DCBH also hosts a central black hole, the two holes will collide and release powerful gravitational waves. These waves could be detectable by the Laser Interferometer Space Antenna (LISA), a European Space Agency/NASA mission expected to fly in the 2030s.

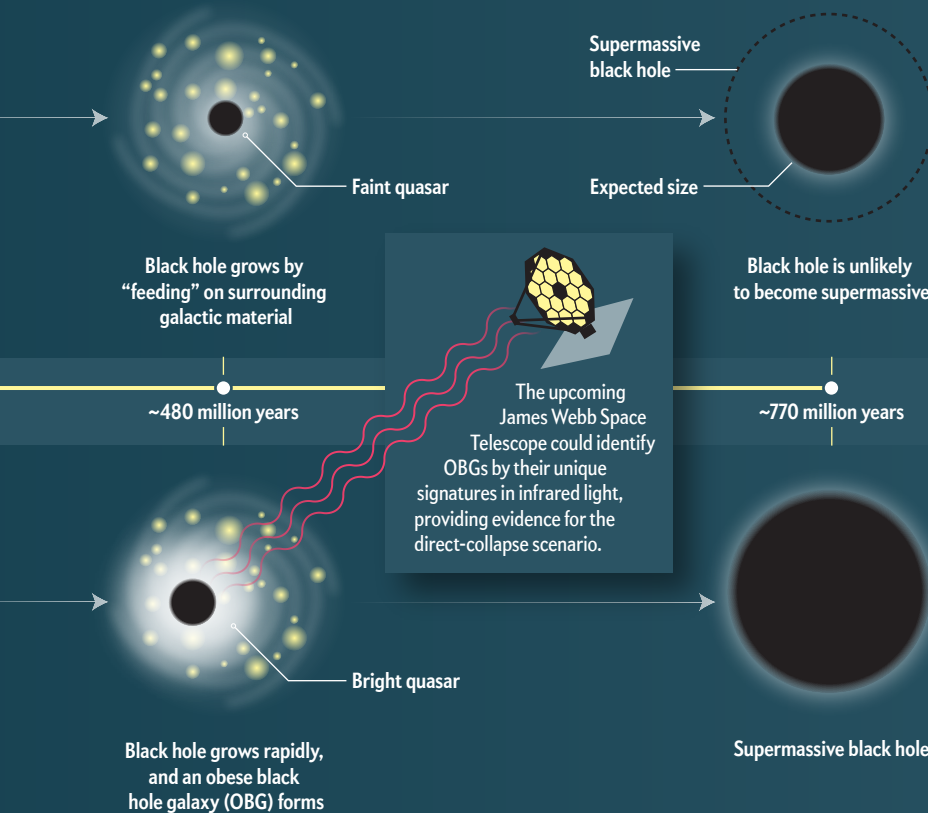
A FULLER PICTURE

IT IS ENTIRELY POSSIBLE that both the DCBH scenario and small seeds feeding at super-Eddington rates both occurred in the early universe. In fact, the initial black hole seeds probably formed via both these pathways. The question is, Which channel created the bulk of the bright ancient quasars that astronomers see? Solving this mystery could do more than just clear up the timeline of the early cosmos. Astronomers also want to understand more broadly how supermassive black holes affect the larger galaxies around them.

Data suggest that central black holes might play an important role in adjusting how many stars form in the galaxies they inhabit. For one thing, the energy produced when matter falls into the black hole may heat up the surrounding gas at the center of the galaxy, thus pre-

Two Ways to Make a Black Hole

The conventional picture of the process that formed the first supermassive black holes (top), which begins with the deaths of the first stars, seems incapable of explaining the enormous size of the black holes that must power the most ancient quasars. A newer idea (bottom) suggests that some gas disks collapsed directly into black holes rather than evolving into stars and galaxies.



venting cooling and halting star formation. This energy may even have far-reaching effects outside the galactic center by driving energetic jets of radiation outward. These jets, which astronomers can detect in radio wavelengths, could also heat up gas in outer regions and shut down star formation there. These effects are complex, however, and astronomers want to understand the details more clearly. Finding the first seed black holes could help reveal how the relation between black holes and their host galaxies evolved over time.

These insights fit into a larger revolution in our ability to study and understand all masses of black holes. When the Laser Interferometer Gravitational-Wave Observatory (LIGO) made the first detection of gravitational waves in 2015, for instance, scientists were able to trace them back to two colliding black holes weighing 36 and 29 solar masses, the lightweight cousins of the supermassive black holes that power quasars. The project continues to detect waves from similar events, offering new and incredible details about what happens when these black holes crash and warp the spacetime around them. Meanwhile a project called the Event Horizon Telescope aims to use radio observatories scattered around Earth to image the supermassive black hole at the center of the Milky Way. Scientists hope to spot a ringlike shadow around the black hole's boundary that general relativity predicts

will occur as the hole's strong gravity deflects light. Any deviations the Event Horizon Telescope measures from the predictions of general relativity have the potential to challenge our understanding of black hole physics. In addition, experiments looking at pulsing stars called pulsar timing arrays could also detect tremors in spacetime caused by an accumulated signal of many collisions of black holes. And very soon the JWST will open up an entirely new window on the very first black holes to light up the universe.

Many revelations are in store in the very near future, and our understanding of black holes stands to be transformed. ■

MORE TO EXPLORE

New Observational Constraints on the Growth of the First Supermassive Black Holes. E. Treister, K. Schawinski, M. Volonteri and P. Natarajan in *Astrophysical Journal*, Vol. 778, No. 2, Article No. 130; December 1, 2013.

Seeds to Monsters: Tracing the Growth of Black Holes in the Universe. Priyamvada Natarajan in *General Relativity and Gravitation*, Vol. 46, No. 5, Article No. 1702; May 2014.

Mapping the Heavens: The Radical Scientific Ideas That Reveal the Cosmos. Priyamvada Natarajan. Yale University Press, 2016.

Unveiling the First Black Holes with JWST: Multi-wavelength Spectral Predictions. Priyamvada Natarajan et al. in *Astrophysical Journal*, Vol. 838, No. 2, Article No. 117; April 1, 2017.

FROM OUR ARCHIVES

The Black Hole Test. Dimitrios Psaltis and Sheperd S. Doeleman; September 2015.

scientificamerican.com/magazine/sa

TECHNOLOGY

are smart- phones really destroying the adolescent brain?

Recent headlines would have us believe that device-hooked teens are mentally and socially doomed. The reality isn't so simple

By Carlin Flora

Illustrations by Aesthetic Apparatus

| **SPECIAL REPORT** | Online February 22

More coverage on the science of adolescence from our *Nature* partners: <https://www.nature.com/collections/adolescence>



Carlin Flora is a freelance writer and author of *Friendfluence: The Surprising Ways Friends Make Us Who We Are* (Doubleday, 2013).



IS ANY AGE GROUP MORE MALIGNED THAN TEENAGERS?

As they roam in packs, they're feared, avoided or told to calm down. They're gawky, narcissistic, hormone-addled, shallow, angsty and entitled. And on top of all that: Have you heard? Smartphones are destroying their brains. Raised in the glow of digital devices, today's teens are depressed, anxious, antisocial and hopelessly distracted.

Smartphones have become a touchstone of adolescence in large part because they are nearly ubiquitous. As of 2015, 73 percent of teenagers in the U.S. had a smartphone, and, as of 2016, 84 percent of American households contained one, according to a new report from the Pew Research Center. With so many devices at their disposal, a full 92 percent of teens—defined in this report as those ages 13 to 17—report going online daily, including 24 percent who say they do so “almost constantly.” Only 12 percent say they go online just once a day.

The latest headlines about teenagers imply that their beloved smartphones are making them mentally ill and socially isolated. Notably, a study published online in 2017 in *Child Development*, led by Jean Twenge, a professor of psychology at San Diego State University, found that today's teens are less likely to drink, have sex, get pregnant, drive, date and work than previous generations. Writing for a general audience in the *Atlantic*, Twenge spun these ostensibly positive trends as something ultimately negative: a worrying reluctance to grow up. She wove in some stats indicating poorer mental health among teens and pinned the gloomy picture on smartphones. “There is compelling evidence,” she wrote, “that the devices we've placed in young people's hands are having profound effects on their lives—and making them seriously unhappy.”

A month later a *New York Times Magazine* cover story reported on an alarming rise of students with “overwhelming anxiety” on college campuses and named social media as a contributing factor. These stories are just the recent wave. Clinical psychologist Sherry Turkle of the Massachusetts Institute of Technology generated dozens of headlines when she published her 2015 book *Reclaiming Conversation: The Power of Talk in a Digital*

Age. She argued that teenagers and adults alike are losing their abilities to understand and pay attention to one another because of the disjointed and solitary nature of electronic communications. These are the abilities, Turkle says, that make us human.

But perhaps unsurprisingly, the generations of adolescents who have come of age in the smartphone era—younger millennials and their successors, Generation Z—aren't irreparably or even especially ruined. And smartphones aren't the clean, easy culprit for behavioral changes observed in 21st-century teenagers. “Over the same time period that Twenge refers to, there have also been improvements in mental health,” says Laurence Steinberg, a professor of psychology at Temple University, who studies adolescent development. Two years ago Twenge herself published a study with two colleagues that concluded that today's teens are happier and more satisfied with life than their predecessors.

Parsing these trends is tough because researchers focus on different aspects of mental health using various measurements. But casting “kids today” in a negative light is a time-honored activity. “Every time there's a new form of entertainment or technology, some adult says, ‘This is killing our kids,’” says Steinberg, who is also author of *Age of Opportunity*, a 2014 book focused on adolescents' great capacity for change. “They said it about dime-store novels and rock and roll and computers. Young people around the world have survived all these things, and I'm sure they'll survive smartphones.”

The very quality that makes teens adaptable is, however, what makes them vulnerable. At the onset of puberty, adolescent brains show heightened plasticity—an increased likelihood to rewire. Driven to seek out novelty and risks, teenagers have flexible neural circuits that help them adjust to environments as they make

IN BRIEF

Recent reports have suggested that smartphone usage is making adolescents more depressed, more anxious and antisocial. But these findings are correlational, and there is still a lot sci-

entists do not know about how these devices affect the development of brains and behaviors.

Social media is often pegged as a culprit of teenager mental health issues.

But some of the troubling effects of smartphone use may involve less sleep, for instance, and not apps themselves.

It is easy to blame new technology for the problems teens face. But issues

such as trauma and poverty are more profound. Postrecession economic instability, for example, most likely has more to do with the rise in anxiety than smartphone use.



Whether it's a pebble thrown against a window or the ring of a rotary phone, any sign of impending social interaction has long excited teen brains.

decisions and learn. As they enter adulthood, the window where connections between brain structures are forged starts to close, hardening their behaviors. "Any experience that people have during the time when the brain is malleable has the potential to affect it," Steinberg says. Kids' brains are affected by all kinds of factors, including parents, friends and school. "Smartphones are not going to have some special significance. That said, the things people spend more time doing have a greater effect on their brains."

Scientists are only just beginning to figure out how smartphone use might affect adolescent development, both behaviorally and neurologically. What is clear is that the extent to which these digital devices are affecting teenage minds is dependent on *how* kids use smartphones, what they are *not* doing because of smartphone use, and the social context in which they use smartphones both at home and beyond.

WHAT WE KNOW AND WHAT WE DON'T

IN 2015 LAUREN SHERMAN, now a postdoctoral fellow at Temple, witnessed firsthand the misplaced panic around smartphones and teens. Knowing that teens are reward-happy—they show greater activation in the reward regions of their brains than either children or adults—she wanted to explore neural responses to social media "likes." Sherman invited a group of high school students into the laboratory to look at a version of Instagram while inside an MRI scanner. She had manipulated a set of her own posts so that some subjects would see them with a high number of "likes," whereas others would see them with just a few "likes." Subjects submitted their own pictures for the study as well.

The subjects were more likely to "like" pictures if they believed the images were already popular. They also showed more activation in regions involved in social cognition and visual attention, as though they were thinking more about the highly liked pictures and scrutinizing them. When the subjects' own photos received a lot of "likes," they showed a response in the ventral striatum, a brain region involved in reward. "That might explain why teens are particularly avid users of social media and why they find it so motivating," Sherman says.

When the study was released in *Psychological Science*, hyperbole set in. "Because it involves the same brain circuitry, the press was saying that 'likes' are just like crack cocaine," Sherman says. "They aren't! Not even a little bit." A New Jersey television station went so far as to declare that "likes" are better than drugs *and* sex.

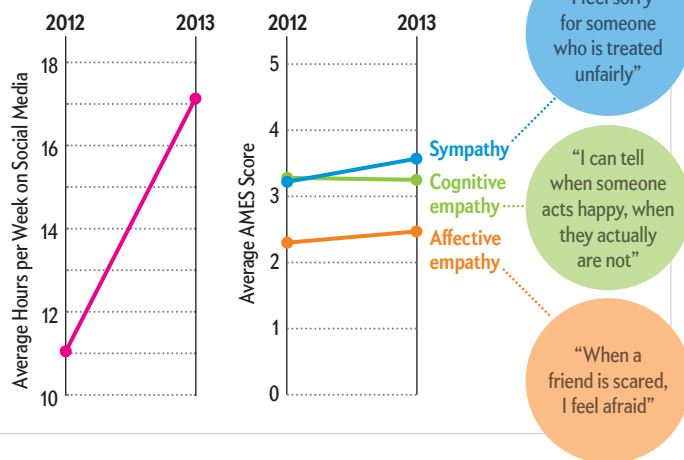
Sherman herself enthusiastically pored over printed-out transcripts of AOL Instant Messenger chats as a teenager. She thinks the "do-do-loo" jingle that signaled a new chat message back then is not so different from a modern teen's "likes." "Neither of these cues is inherently rewarding, like sugar is, but we learn that they represent a social reward," she says.

Whether it's a pebble thrown against a window at night or a long-awaited ring of the rotary phone, we can safely assume that any sign of an impending social interaction has long excited teen brains.

Unlike a rotary phone or a desktop equipped with AIM, though, smartphones are practically appendages, a fact that fuels anxiety about what they're doing to teenagers. "We don't have much clear evidence about how smartphone use is affecting brain development," says Nicholas Allen, director of the Center for Digital Mental Health at the University of Oregon. "Anyone who tells you otherwise is speculating," Steinberg agrees: "There is a growing literature, but it's still quite correlational." Even those correlational results are a mixed bag of positive and negative findings, with some studies pointing to the risks of cyberbullying and others highlighting helpful online resources for teens struggling with personal issues.

Does Social Media Make Teens ... Nicer?

It has been said that social media brings out the worst in teens—and even impairs their social functioning. Dutch researchers Helen G. M. Vossen and Patti M. Valkenburg tested this idea. They surveyed 942 people ages 10 to 14 and gave them a test called the Adolescent Measure of Empathy and Sympathy (AMES), then did the same evaluation a year later. They found that social media use increased over the year, along with the teens' ability to understand and share their peers' feelings.



Long-term research that could show causality would be hard to execute. “You can’t randomly assign kids to have a phone or not,” Steinberg says. Studying teenagers requires obtaining their parents’ permission—an extra logistical challenge. That means that expert predictions are often extrapolations of research on college students. “Sometimes we have good reason to think that the findings from research on young adults may generalize to younger teens, but we have no way of knowing for sure.” Complicating matters is the finding that some brain structures, such as the prefrontal cortex, don’t fully develop until the mid-20s.

Another research design challenge hinges on what exactly a “smartphone” is. It’s a telephone, a camera, a game console and an encyclopedia. Even zeroing in on specific apps teens favor, such as Snapchat and YouTube, is insufficiently broad. “When you’re asking how kids are being affected by social media,” Steinberg says, “it’s like asking about the effect of TV without distinguishing between *Jersey Shore* and *Masterpiece Theatre*.”

Of the emerging narratives surrounding Gen Z youth, one of the most pervasive is that they are more depressed and anxious and that smartphone use is to blame. The reality is that “there is a small yet persistent cross-sectional relation between the amount of time spent online and depression and anxiety,” Allen says, “but we can’t assume it’s causal.” (“Time spent online” is defined differently, too, with some studies focusing on games or social media alone.) One plausible hypothesis, Steinberg says, is that the causal relation runs in the opposite direction. “It isn’t hard to imagine a depressed teenager would rather spend time in her bedroom, online, than go to a social gathering with people from school.”

Larry D. Rosen, a professor emeritus of psychology at California State University, Dominguez Hills, and co-author of the 2016 *The Distracted Mind: Ancient Brains in a High-Tech World*, suspects that while it is possible that kids who are already depressed or anxious use smartphones differently, the influence probably goes both ways. Rosen thinks that social comparison (where social media browsers feel awful about their lives after getting bombarded with rosy versions of everyone else’s) and emotional contagion (where negative online outbursts affect browsers’ states of mind) are possible culprits. Whether or not a teen experiences a self-esteem dip or secondhand moodiness comes down to who they’re associating with online and what exactly they’re looking at.

It is that precise aspect of *how* social media is used that researchers are now testing. Oscar Ybarra of the University of Michigan and his colleagues found that subjective well-being was negatively affected by passive use of social media sites because comparisons sparked envy. But active use—posting content and interacting with others rather than just “lurking”—predicted higher levels of subjective well-being, seemingly because active use creates social capital and makes users feel more connected to other people. In another example, a study by the Harvard Graduate School of Education found that teens who were successfully prompted to critically analyze Instagram streams—acknowledging that the images are “curated” and not representative of reality—had fewer bad feelings, particularly if they previously compared themselves negatively with those in their feed.

Although teens’ moods may be generally resilient to the vicissitudes of social media, other areas of cognitive development are a growing concern. Temple psychologists Harry Wilmer and Jason Chein found a correlation between heavier smartphone use and less of an ability to delay gratification, for example, taking a smaller sum of money in the moment rather than waiting for a larger amount. Researchers do not yet know if impulsive people are more into phones, though, or if phones are making everyone less capable of resisting urges.

For Rosen, a big concern is not just how teens are using their phones but rather the “technological anxiety” and nomophobia (the feeling someone gets in the absence of their phone), that distract them from other tasks. Research has shown that multitasking leads to worse performance on any of the tasks in play. Using an app, Rosen monitored how many times his students unlocked their phone each day. “It was 50 times, on average,” he says, “and they stayed on the phone for about five and a quarter minutes each time.” Most of the near-constant checking in had to do with communication because their top apps were Facebook, Instagram, Snapchat and YouTube. “We know that half of the time people check in, it’s because they get an alert or notification.” Adults seem to be affected, too: a British study showed that just the presence of a phone on a table between two people chatting about a meaningful topic had a negative effect on closeness and conversation quality. The call of the phone is cognitively loud, even when it’s turned off.

Temporary distraction is one thing; potential long-term brain damage from stress is more unsettling. “What I’m con-

SOURCE: “DO SOCIAL MEDIA FOSTER OR CURTAIL ADOLESCENTS’ EMPATHY? A LONGITUDINAL STUDY,” BY HELEN G. M. VOSSEN AND PATTI M. VALKENBURG, IN *COMPUTERS IN HUMAN BEHAVIOR*, VOL. 63, OCTOBER 2016



“Asking how kids are affected by social media is like asking about the effect of TV without distinguishing between *Jersey Shore* and *Masterpiece Theatre*.”

—PSYCHOLOGIST LAURENCE STEINBERG

vinced is happening,” Rosen says, “is that after someone checks in [then stops looking at the phone], cortisol leaks into the system out of the adrenal glands. A little bit of cortisol is fine, but a lot of cortisol is not. As the cortisol builds up, people get anxious. The only way to quell that feeling is to check the phone again.”

Rosen wonders if the steady stream of cortisol will affect the development of the prefrontal cortex—the part of the brain responsible for, among other things, impulse control and decision making. It is the last part of the body to get fatty cells wrapped around its neurons, a process called myelination. “My guess is that young people are using their prefrontal cortex differently and perhaps less efficiently.” He is looking at the prefrontal cortices of “heavy” and “light” tech users with functional

ter at reading facial expressions in their 20s anyway. As for how they are interacting, “you shouldn’t confuse ‘different,’ with ‘defective,’” he says. “Some say their texting style is wrong, but they’re communicating ideas, even if their prose and grammar are not what we’d like them to be.” Instead of looking for deficits, Giedd asks about the trade-offs: “What are their brains better at instead? Sorting through texts? Keeping track of more friends?”

Even the assumption that face-to-face interactions are more satisfying and profound is not always true. Sherman asked her subjects whether there are certain topics they feel more comfortable talking about via digital communications such as texting. They said that if they wanted to say something really emotional and felt like they might cry, they preferred texting. Particularly

near-infrared spectroscopy and has found that, at least while performing one executive functioning task, light versus heavy smartphone users use their prefrontal cortices differently.

DIGITAL LIVES, IRL TRADE-OFFS

SMARTPHONE-WIELDING TEENS have been portrayed as reclusive, lacking in empathy, and even incapable of having “real” relationships with friends or romantic partners. The fear is that smartphone use discourages—or replaces—healthy behaviors, including face-to-face interactions (IRL—“in real life”—as the kids say).

Researchers who study teenagers are not so worried. “There’s no evidence that using social media impairs the development of social skills,” Steinberg says. “The main people kids interact with over social media are the same people they interact with face-to-face.” The irony, according to Allen, is that the opportunity to explore relationships of all kinds, without being under the direct watch of their parents, is what draws many teenagers to their phones in the first place. Connecting via smartphones may even improve empathy.

In 2016 a Dutch study surveyed 942 adolescents and then again a year later. Social media use appeared to improve their ability to understand—and to share the feelings of—their peers during that time frame. Whereas another of Sherman’s studies on how social media affects intimacy did show that in-person chats between two female teenagers yielded the highest level of connectedness, it wasn’t much higher than when they chatted over video. As communication platforms become increasingly audiovisual, Sherman thinks those shifts could bring us all closer together.

But what about incessant texting? Jay Giedd, director of child and adolescent psychiatry at the University of California, San Diego, says teenagers tend to get bet-

because they are often interacting online with real-life friends, a different and maybe even deeper mode of bonding can take place as teens trade disclosures that are difficult to say out loud.

Less benign than texting is the unprecedented access to porn smartphones provide, which might affect how many teens, especially those with other risk factors, develop romantic relationships in real life. “Though there’s no clear evidence, unrestricted exposure to porn could influence their understanding of sexuality and relationships, especially if it’s their earliest exposure to sex,” Allen says. A 2016 study found that about three quarters of teenagers (gender or background made no difference) reported a sexual problem such as low desire or inability to achieve orgasm, with clinically significant levels of distress associated with it. The study’s author, Lucia O’Sullivan, a professor of psychology at the University of New Brunswick in Canada, says that most young people actually tend to habituate to porn. She thinks that general mental health issues and a focus on pregnancy and infection in sex education—rather than a broader exploration of communication and the “how to” of sexual interactions—are more to blame for her finding.

As teens navigate the complex world of sexuality and relationships of all kinds, they are also “finding themselves.” Forming an identity is a big job for teens, and some wonder if smartphone immersion might hinder opportunities for them to come into their own. “Social media is a place where teens are expressing themselves and thinking about how they’re presenting themselves to others,” Sherman says. “One of the early hypotheses was that teens would go online and explore brand new identities, to become somebody else. That largely doesn’t seem to be the case.” That doesn’t mean they aren’t testing slightly different versions of a core identity, though.

Teens are skilled at evading detection and savvy to the cultivation of both public and private selves. “Teens sometimes have their public profile and then a ‘Finsta,’ or fake Instagram account, where they paradoxically show their real selves,” sharing silly faces or unedited streams of thoughts, Sherman says. The trend has likely influenced the functionality of Instagram. “Now it’s possible to link two accounts, which was probably a direct response to users creating secondary accounts,” she adds. “Adolescents bend these online environments to fit their own purposes. We spend a lot of time talking about the effects of social media on teens, but teens are interacting with these tools—and changing them. It’s a bidirectional relationship.”

Theo Klimstra, an associate professor of developmental psychology at Tilburg University in the Netherlands, sees smartphones as a double-edged sword for identity formation. “One thing that teens typically do is look for people who are like them, to find a mirror,” he says. If you grow up in an area where there are very few people like you, then social media makes it possible

The Key to a \$300-Million Study of Teen Brains? Smartphones

What if the oft-maligned smartphone could protect teenagers’ mental health and help researchers learn about other aspects of adolescent development?

At least 50 percent of mental illnesses start by age 14, and 75 percent start by age 24, a fact that Jay Giedd, director of child and adolescent psychiatry at the University of California, San Diego, has spent his career trying to unpack. The reason symptoms emerge at that time has to do with the plasticity of teen brains and the dynamic changes occurring during this period, which is also why they respond well to treatment. That is, when they get help: “The average time between when someone gets depression and when they get treatment is 10 years,” Giedd says. “It’s the shame of our profession. One in seven kids is depressed,” and very few are getting treatment.

The symptoms of mental illness are often things such as moodiness, which all teens experience. “How do you know if a teen is just being a teen? I’ve been a psychiatrist for almost 30 years, and it’s hard to tell,” Giedd says. “The key to diagnosis is change. But the baseline might be all over the place—some people are outgoing; others are shy. If we have someone come in only once every six months, and we ask them, ‘How happy have you been?’ you’re lucky if you get how happy they were that morning.”

Enter smartphones: by tracking a teen’s online activity, researchers can detect changes because there is a reliable baseline. As such, Giedd is optimistic that mobile technologies could one day help teens more than medications.

Now a landmark project is testing such applications to see the effects of smartphones—alongside other factors—on teen brains over time. The ABCD (Adolescent Brain Cognitive Development) study has received funding of \$300 million, “which is more than the entire history of adolescent research around the world up to this point,” Giedd says.

The study is headquartered in San Diego but will unfold at 21 sites around the country. The team has so far recruited about 7,000 nine- and 10-year-olds (the target is 11,500) who will be followed for at least the next 10 years. Their brains will be scanned every two years, and they will be tracked by smartphones and other apps every three to six months. The first round of data was released in December 2017, and all data will be freely available for other researchers to use.

Giedd predicts that the brain scans will show subtle but real changes over time, not in the size of brains but in the ways they are connected. “The amount of data coming into our world has vastly increased, and I think that will show up in parts of the brain that deal with prioritizing and scanning. It’s possible it will be to the point where you can say, ‘Here’s a digital-age brain, and here’s a non-digital-age brain.’ But even with autism and schizophrenia, we can’t really do that.” —C.F.

to find a kindred spirit. Many researchers point to the example of gay teens who do not feel they can come out in their own towns but can find positive role models and communities online. The potential downsides, Klimstra says, are the tyranny of choice and the possibility of soul-crushing feedback. The Internet could paralyze teens with its overwhelming array of possible selves and damage their self-esteem with extreme reactions on social media.

Even if smartphones are not making teens antisocial or (more) confused about who they are, they do seem to be stealing one adolescent essential: sleep. Overall, teens are sleeping less than in the past. A summary of data on 690,747 children from 20 countries, dating from 1905 to 2008, found that they sleep more than an hour less than young people did 100 years ago.

Sakari Lemola, an assistant professor of psychology at the University of Warwick in England, recently found that teenagers with smartphones fall asleep later at night. “This is probably because they’re engaging with social media, communicating with friends and watching YouTube,” Lemola says. “We also found that electronic media use around bedtime was related to decreased sleep duration and increased symptoms of insomnia. Short sleep and poor sleep quality were in turn related to depressive symptoms.”

There are several possible connections, Lemola says. Modern flat screens emit a larger amount of blue light, which suppresses melatonin, a hormone produced by the pineal gland at night or in the dark that regulates our internal clocks. Getting messages or comments from friends on social media is arousing for teens and makes it more difficult for them to fall asleep. And it’s hard to shut off the phone when endless entertainment beckons.

Lemola points to another recent study showing that, in young adults, poor sleep is a contributing causal factor for serious mental health problems such as psychotic symptoms. “On the one hand, I’m confident there is a majority of teenagers who are able to adjust well to the new opportunities offered by social media,” he notes. “On the other hand, there is a minority of more vulnerable teenagers who are at higher risk for poor mental health compared with generations before them. It is likely that increases in electronic media use and decreases in sleep quality and sleep duration have played a core role in mental health, although other changes in the lives of teenagers, from urbanization to stress at school, can also play a role.”

When Steinberg is flagged down by a concerned, stressed-out parent, he asks, “What is your child *not* doing because she’s spending time on her phone?” If she’s not sleeping, exercising, studying, and stimulating her mind with novel and challenging activities, then that’s not healthy.” Beliefs about what constitutes “novel and challenging” might also be shifting, though. “Before if someone asked me what’s better for a teen: a violin or the video game *Assassin’s Creed*, I’d think it was a joke question,” Giedd says. “But I’ve come to see that *Assassin’s Creed* requires strategy, memory, pattern recognition and reflex skills. And watching well-produced videos is probably a better way to learn than reading. Those words are hard for me to say, but in terms of how the brain absorbs information, it might be true.”

ADULTS THESE DAYS

WHEN IT COMES TO THE THREATS that teenagers face, shiny new technologies are a more interesting focal point than familiar and entrenched ones. That bias can skew our sense of proportion: along with poor sleep, Allen says, family conflict is a key source of mental health problems for teens. “Conflict and stress affect the brain, as does a lack of warmth and support. Why worry about the effect of phones when we have so much evidence for these other factors?” Steinberg agrees, saying the issues we should be focused on are trauma, poverty, exposure to violence and hard drug use because they have a huge influence on teenage development.

Smartphone anxiety could simply be a cover for the difficult parts of watching a child change and grow up. “We see that our kids are not as interested in spending time with us or are engaging in some kind of deviant behavior—all those things we associate with adolescence generally,” Sherman says. But instead of ac-

cepting the changes as normal, “we say, ‘Okay, what’s different? Oh! It’s this new technology.’” After all, Gen X-ers and Millennials spent their teen years glued to the television or immersed in primitive iterations of electronic communications.

It is also helpful to take the anthropological view, Klimstra says. Today’s teenagers are “growing up in a very different world. From our perspective, selfies and social media might look narcissistic, but it’s all context-related.” And theirs is a context infused with economic insecurity. “Unemployment is high in many parts of the world. It makes it really hard to start a life as young person, to get away from your parents, and to become financially and psychologically independent,” Klimstra adds. “That’s more of a threat than smartphone use.”

Researchers do see opportunities to temper the negative effects of smartphone use. Rosen urges teens to “not be a Pavlov’s dog and turn off the notifications.” He also advises parents to model good behavior by not yanking out their own phones so much. It is a big unanswered question: How are smartphone-obsessed parents affecting teenage brain development if they themselves are less engaged and present with their kids?

“In the U.S., parents give young people a phone at 12 and say, ‘Good luck with fake news, bullying and porn.’” Allen says. “We expect teens to grow up immediately and deal with the adult world. We should scaffold those experiences and shape them successively over time, allowing teenagers to be more and more independent. It’s clearly an area where education and public policy come into play.” Giedd agrees: “The most sought-after therapist in the world isn’t Dr. Phil, it’s Siri. She fields more mental health questions than anyone. That’s not Apple’s responsibility. How can we do better if this is where teens are going to turn?”

Because researchers agree that having a close and caring relationship with parents is one of the most important contributors to an adolescent’s positive mental health, the best thing parents can do is bond with their teens around tech use. “Ask what they find compelling about their phones,” Allen says. “Ask them what their fears and their interests are. That kind of discussion is much more productive than saying, ‘Put the phone down at the table.’”

A little faith in scrappy teen spirit can also offset smartphone panic. “The reason we’re here and Neandertals aren’t is because we have teenagers,” Giedd says. “Neandertals didn’t really have teenagers; at 12 they had their own children. Neandertal tool use didn’t change at all for about 200,000 years. Their brains were bigger than ours, but what they couldn’t do is adapt when the climate started changing. By its very design, the teen brain adapts to its environment. Today’s teenagers might not memorize how high mountains are and how long rivers are, but they will be able to find the signal in the noise.” ■

MORE TO EXPLORE

Adolescents’ Electronic Media Use at Night, Sleep Disturbance, and Depressive Symptoms in the Smartphone Age. Sakari Lemola et al. in *Journal of Youth and Adolescence*, Vol. 44, No. 2, pages 405–418; February 2015.

The Teenage Brain: A Neuroscientist’s Survival Guide to Raising Adolescents and Young Adults. Frances E. Jensen, with Amy Ellis Nutt. Harper, 2015.

FROM OUR ARCHIVES

Generation Z: Online and at Risk? Nicholas Kardaras; *Scientific American Mind*, September/October 2016.

scientificamerican.com/magazine/sa

REDACTED

Is the Food and Drug Administration withholding [REDACTED] drug trial data to protect the [REDACTED] corporate secrets of [REDACTED] pharmaceutical companies?

By Charles Seife



The Food and Drug Administration is seldom accused of being too transparent. But in late September it looked like the agency had overshared. In an attempt to achieve the “greatest level of transparency,” the FDA caused the stock prices of four biotech companies to hemorrhage. Jittery traders, sifting through scraps of context-free information provided by the agency, dumped their drug stocks, triggering a brief but brutal plunge.

It shouldn't have happened that way. The FDA's attempt at transparency was far from revolutionary; it was the release of a Web interface to a drug side-effects database known as the FDA Adverse Event Reporting System (FAERS). Not only was FAERS already public, albeit in a slightly less user-friendly form, the database is also messy, context-free and subject to all sorts of biases and errors, making it nigh impossible to interpret properly. It's not something that the public should be very excited about; FAERS certainly isn't a precise enough tool to tell market speculators whether to dump a stock, any more than a sledgehammer is a precise enough tool to amputate a limb. Yet soon after the FDA announced the new interface, the stocks of four companies—Sarepta

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Therapeutics, Ionis Pharmaceuticals, Biogen and Acadia Pharmaceuticals—plunged.

The underlying cause of the bloodbath, ironically, is the FDA's opacity regarding certain important data about the performance of drugs. Data about adverse events patients had when taking the drug. Data that can give us insight into what elements of a clinical study researchers haven't made public. Even data hinting at research misconduct in key drug trials. The agency refuses to release these data, yet without them, the public is unable make an informed decision about whether or not to take a drug. The reason: doing so might hurt a pharmaceutical company. The FDA's refusal is a graphic demonstration of how the agency feels obliged to protect corporate secrets, even at the expense of consumer safety. That's the precise opposite of transparency, and in the FDA's case, it might be putting people's lives at risk.

The FDA has the unenviable position of making life-and-death decisions every day. No matter how good the agency is, some of the time it's going to get a decision wrong, and Americans will be put at risk and even die.

When things go wrong, though, it's often damnably hard to figure out precisely what happened. The FDA has long had a reputation for opacity; even congress-people, who have the power of subpoena, have been frustrated by the agency's refusal to provide basic information that could help reveal the true story behind a bad decision. A decade ago Senator Charles Grassley of Iowa, when looking into a case where the FDA made a bad call in approving a dangerous drug, said the FDA put up “every excuse under the sun” to prevent the release of requested documents:

“The Department [of Health and Human Services] and FDA say ... they have been responsive to the Finance Committee's Ketek investigation because they made available millions of pages of documents to the Committee. But what they provided is quantity, not quality.

“They delivered hundreds of pages simply marked, for example, ‘57 pages removed,’ or ‘43 pages removed.’ ... Other documents have whole pages, paragraphs or sentences redacted with no explanation for what has been withheld or redacted and why. In fact, the FDA redacted some of the same documents differently and even redacted one of my own letters to them on a different matter....”

Reporters like me have encountered similar roadblocks when covering the FDA. (For example, when I was trying to investigate how the agency was handling a massive case of fraud that undermined the data behind a number of approvals, the agency refused to release the names of the drugs that were affected.) On

occasion, the agency is not just slow to release information about problems it is finding with drugs, but it has even been willing to reassure the public about products that later turn out to be dangerous. So the public can't rely on the FDA to release everything that is important to know, and objective data that the agency uses to make its decisions have become quite valuable for understanding not just the FDA's decision process but also whether it has been making good calls or bad ones.

It so happens that one of the most controversial calls of the past few years has to do with one of the companies involved in September's stock plunge, Sarepta. In September 2016 the FDA decided to approve Sarepta's first drug, eteplirsen. Eteplirsen is a cleverly designed compound that's supposed to help certain patients with Duchenne muscular dystrophy (DMD), a deadly disease that strikes young boys.

Initially the FDA's answer was that the drug should be rejected, but Janet Woodcock, the head of the agency's Center for Drug Evaluation and Research, overruled the FDA's own review team, a very unusual step, and declared that the drug should be allowed to come to market. Since then, a cloud has hung over eteplirsen as third parties, such as insurers, physicians and independent researchers, try to figure out whether or not the drug actually works.

The agency has released thousands of pages of information about eteplirsen, but I knew that there was a lot of critical information missing from those pages—information that might help determine whether the agency approved an entirely ineffective drug based on faulty clinical trials and undue industry influence or whether there is unjust suspicion about eteplirsen's safety and effectiveness.

Last May I sued the FDA under the Freedom of Information Act to understand the eteplirsen decision better; the lawsuit was designed to force the agency to release information about the drug and the FDA's decision. Late last year the agency released thousands of pages of previously undisclosed documents about eteplirsen and its approval. Despite the volumes of papers the FDA is disclosing, once again, the agency is far from transparent. What's so striking in those documents is not the information that the FDA is releasing but the information that it refuses to release.

For example, in several of the documents, frequently encountered adverse events—side effects and other negative consequences that occur during a treatment—are occasionally redacted. In some cases, other sources give us a hint of what these adverse events likely are. For example, one document states that “the most commonly reported [adverse events] included procedural pain, oropharyngeal pain, [REDACTED], cough, nasal congestion, and extremity pain.” Luckily, one table below a nearly identical redacted section is intact, and it implies that the censored portion is drawn from the following: hypokalemia (low levels of potassium), vomiting, “balance dis-

IN BRIEF

In September 2016 the FDA took the highly unusual step of approving a drug, eteplirsen, against the advice of the agency's experts.

Faced with a Freedom of Information Act request for data on eteplirsen, the FDA released heavily redacted documents suggestive of several adverse effects and even possible scientific misconduct.

The FDA's stated reason for withholding additional data suggests that the agency may be more interested in protecting the drug-maker than in promoting public safety.

order,” headache, fever, back pain or a certain kind of blood clot known as a hematoma. (Vomiting and balance disorders are listed as possible side effects on eteplirsen's label.) In other cases, though, it's all but impossible to figure out what the FDA is attempting to block us from seeing: an updated listing of adverse events in a follow-up study says that “the most commonly experienced [adverse events] were procedural pain [REDACTED].” Also expunged from the document were possible indicators of kidney problems and issues related to blood clots.

The FDA has to make an active decision to prevent the public from seeing what's behind those black bars in the document. And it's not just side effects where the FDA seems determined to prevent the public from getting the full picture about the scientific case for eteplirsen.

A drug approval revolves around how patients perform with respect to so-called outcome measures in key clinical trials. Outcome measures are

the yardsticks by which patient improvement is measured. For a muscle-wasting disease like DMD, there are many possible measures to choose from: how far a patient walks in six minutes, how long it takes to run 10 meters, how much time it takes to get up from the floor, and so on. But it's crucial to choose those yardsticks ahead of time and publish the results from all of them; otherwise it's possible to game the system by “outcome switching.” It's easy to make a worthless drug seem effective by hiding the outcome measures that don't show good results and publishing only outcomes that do. It's like going through a deck of cards and selecting only the ones you want; you're guaranteed a royal flush every time.

Eteplirsen researchers observed at least nine outcome measures designed to gauge patients' muscle strength and tone. The results from at least two of these measures have been buried: they're missing from

the peer-reviewed literature. That's not unexpected; drug companies and researchers do this all the time. But it's surprising that the FDA would be complicit in hiding buried outcomes. The agency censors all reference to the results of those measurements and even to the names of the outcome measures that disappeared.

Pretty much every mention of those two measures is blanked out. Tables: censored. Sarepta's evaluation of these outcome measures: censored. Even tables of contents: censored.

From other sources, I have been able to piece together that the two missing outcome measures are a “nine-hole-peg test,”

in which a patient is timed on putting pegs into holes, and “maximum voluntary isometric contraction testing,” or “MVICT,” which measures the force with which a patient pulls against a strap. The results for these tests are nowhere to be found, even though they've been in Sarepta's hands for years. All my requests for the results of these missing measurements—from the researchers and from Sarepta itself—have been refused. And this is even though eteplirsen researchers apparently “presented” the results in a poster session at a meeting last October—not long after the FDA started handing over documents in response to my lawsuit. (Another poster presented at the same meeting is on Sarepta's Web site, yet there's nothing on the missing outcome measures.) Smart money is that the results of the nine-hole-peg test and MVICT have been redacted because they hurt eteplirsen's cause rather than help it.

More evidence of outcome switching has to do with the number of certain types of white blood cells, known as CD3, CD4 and CD8 cells, found in each patient's muscle. It's not clear precisely what the researchers had in mind, because Sarepta's description of this “key secondary efficacy endpoint” on the national clinical trial registry Web site was vague. But we do know that sometime between July 2011, when the trial began, and July 2015, three years after it ended, the “key secondary efficacy endpoint” had mysteriously become a test of walking; the white blood cell

outcome measure was nowhere to be found. (Neither the lead investigator of the eteplirsen trial nor Sarepta would answer questions about what the outcome measure was or what the results were.) The FDA knows the answers, but it ain't telling: the major references to the analysis of these white blood cells tend to have a big block of censored text where the results should be.

Outcome switching is a way for researchers and drug companies to distort the context around a clinical result, to make a drug look more effective or safe than it really is. The FDA's job is supposed to be exactly the opposite—to counter industry-distorted science and provide an objective measure of safety and effectiveness to help physicians make the best choices for their patients. Yet when it comes to eteplirsen, the FDA is siding squarely with the industry and against the public interest.

This is even true when it comes to allegations of outright fraud. One of the most alarming documents to come out of my lawsuit is a chain of e-mails in which an FDA reviewer suggests that Sarepta or eteplirsen researchers might be manipulating and misrepresenting scientific images. Of most concern are so-called Western blots.

Scientists use Western blots—which, when photographed, look like a bunch of messy stripes—to gauge the types and amounts of protein in a sample. Western blot images are ubiquitous in the medical and biological literature, but because they're such simple images, they're easy to fake, and blot fraud is surprisingly common.

The eteplirsen studies had Western blots—and those images raised the eyebrows of an important FDA reviewer: “There seems to be reason for concern of misrepresentation of the data,” he wrote. Apparently he was concerned that the images were misleading and perhaps even manipulated in an inappropriate way.

Nationwide Children's Hospital pediatrician and lead eteplirsen researcher Jerry Mendell denies allegations of manipulation of images. “The studies were FDA reviewed/audited [and the drug was approved] and the articles were peer reviewed,” he wrote in an e-mail. Sarepta refused to discuss any allegations of misconduct.

Who's right? It's impossible to tell. We can't say whether or not there's scientific misconduct without looking at the raw, unprocessed Western blot images and comparing them with the ones that are published. Mendell did not respond to requests for those unprocessed images. Nor did Sarepta.

But those originals are in other hands, too. The FDA has them, and it was a big fight to get them. After extensive negotiations through my lawyers, the FDA turned over the documents—the very morning that this article was going to press. It has yet to be seen whether, in fact, the allegations have merit, but it is clear that the FDA certainly hasn't brought this issue to the public's attention; on the contrary, when pressed, agency officials denied any suspicions of misconduct. (A different reviewer, shortly after eteplirsen was approved, said that he viewed the issue as “sloppy sci-

ence” rather than misconduct.) And the FDA appears to be actively withholding similar data: another place where such raw images reside is redacted, as are major portions of the analysis that might cast light on how the data were processed. The FDA won’t release them.

Why would the FDA, an agency trying to be more transparent, block evidence of outcome switching and even hide references

to a medication’s side effects? The reasoning takes a bit of unpacking, but it boils down to a simple principle: the FDA is refusing to release this information because it might hurt Sarepta, the maker of eteplirsen.

The FDA has stated that the redacted sections represent “trade secrets and commercial or financial information obtained from a person, and privileged or confidential.” In this particular case, this tends to mean that the release of the information will cause “substantial competitive injury” to the company that turned it over to the FDA.

Before releasing the documents, the agency allowed Sarepta (which is intervening in my lawsuit against the FDA) to suggest redactions that it felt would cause such harm or are exempt from release for other reasons. And sure enough, Sarepta thinks that releasing certain adverse events and endpoints will hurt Sarepta and help its competitors. (For example, Sarepta’s present position is that releasing which endpoints were used, much less the results of the tests, would give “invaluable information to competitors.”) If the agency didn’t agree—if it didn’t think that Sarepta was correct—it would still be required by law to release this information or, at the very least, to come up with a different reason for the redactions. So to all appearances, the FDA believes that in these cases releasing this information will hurt Sarepta and refuses to turn it over.

That’s it in a nutshell. The FDA is blocking access to very basic information about eteplirsen—censoring side effects and hiding evidence of missing outcome measures—because releasing that information would hurt Sarepta. (The FDA refused to answer any of my

questions about its conduct, citing the lawsuit as a reason.) The public’s interest in knowing the truth about a drug is secondary to the interest in protecting a company from harm.

This is toxic for our confidence in the FDA and in the drugs that it allows to come to market. It may well be that there’s no real case for scientific misconduct in the eteplirsen clinical trial. It may well be that we already know about all the drug’s important side effects. Heck, it’s even possible that the censored and missing outcome measures strengthen the case for the drug’s effectiveness rather than weaken it. But the FDA’s willingness to consider such basic information about a drug’s performance as a “trade secret” or “confidential commercial information” and block it from public view means that we won’t—and can’t—know. There’s a haze of uncertainty around every single one of the FDA’s decisions.

And this, ultimately, was the trigger of the stock plunge at the end of September. When the FDA made its adverse-events database easier to search, investors immediately started searching through it and turned up scary-seeming reports of deaths and injuries, which caused a loss in confidence about certain drugs—in Sarepta’s case, about eteplirsen. (Sarepta’s stock has since recovered.) Even though these adverse-events reports weren’t terribly useful for evaluating the drugs’ safety, every little scrap of new data can send shudders through a market starved for information.

Had the FDA been more scrupulous about serving the public’s interest—sharing all information about adverse events, endpoint switching and even intimations of fraud—the market wouldn’t have been so reliant on the noisy and hard-to-interpret data in the adverse-events database. The public would have much more confidence in an FDA that’s truly transparent than one that is willing to call such information a “trade secret” or “confidential commercial information” and hide it from view.

In other words, it’s impossible to trust an agency that worries more about a drug’s side effect on a company than on a patient. ■

MORE TO EXPLORE

FDA Grants Accelerated Approval to First Drug for Duchenne Muscular Dystrophy.

FDA News Release. FDA, September 19, 2016. www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm521263.htm

Measuring Clinical Trial Transparency: An Empirical Analysis of Newly Approved Drugs and Large Pharmaceutical Companies.

Jennifer E. Miller et al. in *BMJ Open*, Vol. 7, Article No. e017917; December 2017. <http://bmjopen.bmj.com/content/7/12/e017917.long>

FDA documents about eteplirsen (author communication): www.accessdata.fda.gov/drugsatfda_docs/nda/2017/exondys51.cfm

FDA Adverse Events Reporting System (FAERS) public dashboard: <https://fis.fda.gov/sense/app/777e9f4d-0cf8-448e-8068-f564c31baa25/sheet/6b5a135f-f451-45be-893d-20aaee34e28e/state/analysis>

FROM OUR ARCHIVES

[How to Spin the Science News](#). Charles Seife; October 2016.

scientificamerican.com/magazine/sa

An underwater photograph of a kelp forest. Numerous fish, likely rockfish, are swimming among the dark, silvery kelp fronds. The water is a deep blue-green color. The scene is captured from a slightly low angle, looking up towards the surface.

BIODIVERSITY

Troubled Waters

Big marine reserves look good on maps, but it takes tough rules close to shore to improve fisheries and biodiversity

By Olive Heffernan

ROCKFISH THRIVE in a kelp forest near Monterey, Calif., where protected areas have strict controls.



LAST JUNE RODOLPHE DEVILLERS

stood on the Canadian parliament floor in Ottawa and gave the ministers there a stark warning. Devillers, a geography professor at Memorial University of Newfoundland, told them they should not allow industry to operate inside marine protected areas (MPAs), parcels set aside to safeguard ocean life. If the government continued to issue lax restrictions inside the nation's reserves, he said, "the Canadian MPA network is unlikely to bring the benefits the government and Canadians expect." The day before, he and 14 other scientists had sent a damning letter to two of the ministers, complaining about Canada's weak actions. They had also sent a copy to the media, and by the afternoon the story had become national news.

In particular, Devillers cautioned parliament against making this blunder in the highly anticipated Laurentian Channel MPA, an ocean reserve that would cover more than 11,000 square kilometers between Cape Breton in Nova Scotia and Newfoundland. It would be Canada's largest marine sanctuary ever, intended to protect leatherback turtles, porbeagle sharks, sea pens and other at-risk residents. It would also provide a safe stopover for migrating mammals such as the endangered blue whale and North Atlantic right whale.

A week later, on June 24, Canadian fisheries minister Dominic LeBlanc went public with the government's Laurentian Channel plan. In 80 percent of the reserve, corporations could drill for oil and gas. Ships could come and go as they pleased anywhere in the MPA. The size of the sanctuary had been cut by 33 percent so that big companies could still exploit major fishing grounds, and the number of sensitive species covered had dropped from 16 to six.

Worldwide, there are more than 15,000 MPAs, and the vast majority allow commercial activity. Even in the acclaimed Great Barrier Reef Marine Park, people can fish for endangered sharks, including hammerheads. The lenient designations "are nonsense if you compare this to protection on land," Devillers says.

To be effective, MPAs must be strict. That means either no-take—where all extraction is banned—or low-take—allowing only artisanal fishing for local consumption. Reserves this strict cover just 1.8 percent of the earth's seas.

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Already humans have fully exploited or overexploited 89 percent of global fish stocks and destroyed many of the world's coral reefs. To safeguard a healthy assortment of marine life, scientists say we need to sequester at least 30 percent of the seas in MPAs distributed worldwide. Crucially, much of that space should be close to busy shores. Done properly, this approach could bring enormous benefits for oceans and humans. If a region is truly left alone for long enough, fish and biodiversity can rebound even in places that were once decimated. More and larger fish spill over into neighboring waters, too. Smarter MPAs can even make marine ecosystems more resilient to other pressures, such as pollution, warming and acidification.

But right now the 30 percent goal is a long shot. Countries that have ratified the United Nations Convention on Biological Diversity have agreed to place 10 percent of their waters within MPAs by 2020. With less than two years to go, national leaders have been scrambling to draw up boundaries. In the rush, some have created weak reserves that have few restrictions, such as the Laurentian Channel. Other nations, including the U.K., have created vast no-take sanctuaries around remote overseas territories, such as Pitcairn Island in the Pacific. These places have no large commercial fisheries or other industry, so it is unclear if they offer much conservation benefit. "All we're doing is rebadging bits of ocean," says Bob Pressey, an expert in conservation planning at James Cook University in Australia.

Moreover, governments appear to close MPAs or move boundaries at will, even though the areas need to be in place for at least 10 years to provide any significant gain. In December, U.S. Secretary of the Interior Ryan Zinke called on President Donald Trump to open three marine national monuments to commercial fishing: Northeast Canyons and Seamounts, Rose Atoll and Pacific Remote Islands. Australia is reconsidering the Coral Sea Marine Park—a stunning expanse that is home to corals, fish, turtles, seabirds and whales—for industrial tuna fishing.

"As a conservationist, you have to welcome the closure of hundreds of thousands of square kilometers of ocean," says Peter Jones, who researches environmental governance at University College London. "But the very next question is: Is it really going to be effective?"

IN BRIEF

Nations have rushed to announce big marine protected areas, which can help sea creatures thrive, but many of the zones are in waters where little fishing occurs and few activities are hurting ocean life.

Countries should impose more strict no-take or low-take zones close to shore, where industrial activity is greatest. International agreements are also needed for the high seas.

California has made itself legally bound to follow scientific advice for protecting coastal waters, a benchmark for other states. And nations have reached one model agreement for international waters.



1 SANCTUARIES, new and planned, will safeguard penguins in Antarctica's vast Ross Sea (1), leatherback turtles between Nova Scotia and Newfoundland (2), and porbeagle sharks along Canada's southeastern shores (3).



TRICKY TARGETS

NATIONAL GOVERNMENTS started designating large reserves on land more than a century ago; Yellowstone National Park was established in 1872. Progress in the seas has been much slower, but recent excitement has been high. Ten of the world's largest MPAs, many as big as some countries, have been created in the past two years, spurred by political targets such as the U.N.'s biodiversity goals. In 2016 President Barack Obama expanded the Papahānaumokuākea Marine National Monument, which surrounds the northwestern Hawaiian Islands, to twice the size of Texas.

Large MPAs, even in remote regions, can make marine ecosystems more resilient. But what happens within the reserves is just as important as size. Currently 86 percent of marine protected area globally is tied up in just 21 large reserves, most located in remote tropical waters where little fishing or other industry occurs. Few MPAs target populated, temperate regions, says Graham Edgar, a marine conservation biologist at the University of Tasmania. Of more than 17,000 marine species studied recently, only about 500 had more than 10 percent of their range within an MPA.

To improve marine biodiversity, MPAs are needed in almost every country's coastal waters. But trying to designate them in developed areas will be "very unpopular," says Robert Richmond of the University of Hawaii at Manoa. Only 0.03 percent of coastal waters along the U.S. mainland are under no-take restrictions. Less than 1 percent of Australia's coastal waters are set aside as no-take or low-take. And less than 0.01 percent of U.K. mainland coastal waters are no-take zones.

Of course, nations need stretches of ocean that they manage for fisheries. But problems arise when these places are counted as MPAs. This issue is acute in the U.S. In totting up its MPAs, it routinely includes areas that manage just one specific fishery or activity. For example, experts say that an MPA around the Aleutian Islands prohibits only bottom trawling and does not address the region's overall health or biological diversity. Calling these sites MPAs is misleading because it "creates false benchmarks of national and global protection," says Heather

Welch, a conservation expert at the University of California, Santa Cruz.

As the only U.N. member state to not ratify the Convention on Biological Diversity, the U.S. has lax classifications for MPAs, Welch says. If the country ratified the convention and adopted the categories for MPAs that are set by the International Union for Conservation of Nature (IUCN), its estimates would be more in line with those of other nations. Under those rules, the U.S. would be forced to declassify 28 percent of its MPAs and 51 percent of its protected waters, according to an analysis by Welch.

Other wealthy nations, such as the U.K., draw a distinction between MPAs and areas just managed for fisheries. Yet many of their MPAs are "weak"—they have few restrictions. And the U.K. counts these waters toward the U.N. goal of protecting 10 percent of the ocean by 2020.

The trouble stems in part from a 2008 ruling by the IUCN, which sets the criteria for nature reserves. It adopted two new categories—for both sea and land—that allow for multiple uses or sustainable exploitation. The rationale was that this action would help poor countries establish some level of safe waters while not undermining their dependence on the ocean for food.

But prosperous countries are now using these lenient categories to create MPAs that are wins for politicians who want to look like they are committed to conservation, without having to impose or enforce prohibitions on industry or the public. "This is beginning to blur the boundaries between protected and exploited areas," Jones says.

CALIFORNIA SUCCEEDS

ALTHOUGH CREATING EFFECTIVE MPAS in areas people depend on is difficult, it can be done. Under international law, countries control the use of ocean resources—from fishing to oil drilling—in a so-called exclusive economic zone that extends 200 nautical miles (370 kilometers) out from their shoreline. The law also allows them to preserve those waters. In the U.S., states divide up this zone. Back in 1999 the California Marine Life Protection Act set up a network of MPAs to safeguard valued regions, such as those near Big Sur and Monterey. After two failed attempts at implementing the legislation, in 2004 the state devised an initiative to guide how the MPA network would be formed.

The legislation instructed planners to use the best available science to determine MPA locations and to involve local stakeholders, such as fishers, shippers and divers, in planning. Funded with \$38 million from a public-private partnership, the process took until 2012 to complete. Now a network of 124 MPAs covers 16 percent of state waters (excluding San Francisco Bay); three fifths of the area is a designated no-take zone.

California is already reaping rewards. A 2015 study of 13 MPAs around the northern Channel Islands off the coast of Santa Barbara found that after 10 years of protection, species fished there, such as rockfish, were becoming bigger and more numerous. The fish were also expanding into neighboring areas. Conservationists hope to see similar results statewide.

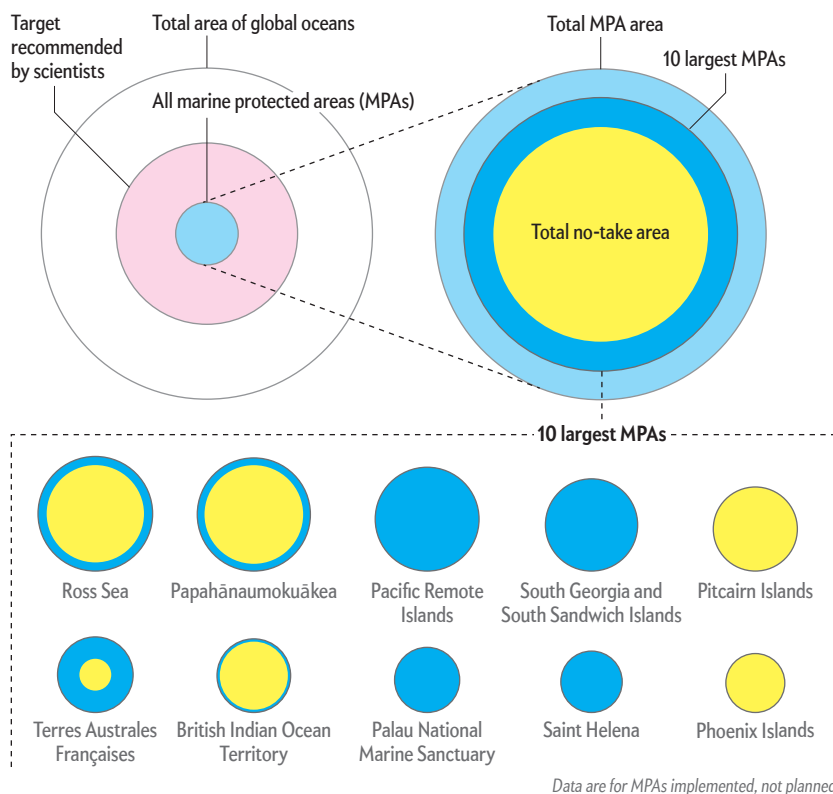
Elizabeth De Santo, an expert in marine planning at Franklin & Marshall College, says that California succeeded because it had a legal mandate to follow scientific advice and involved scientists throughout the process. It also took into account the needs of local communities and ensured that there was “buy in” from everyone.

In 2009 the U.K. tried to mimic this process. It had around 500 MPAs but just two tiny no-take zones, one covering a paltry 2.6 square kilometers in Scotland’s Lamlash Bay. So the government started to plan a network of marine conservation zones, or MCZs. Following long consultations with stakeholders, in 2011 a scientific panel recommended 127 sites for protection, plus an additional 65 no-take areas.

The proposals faced all kinds of opposition—from Oil & Gas UK, an industry group that claimed interference with exploration; from the Port of London, which said that MPAs were being

Circles of Life

Countries are designating large swaths of ocean as marine protected areas, or MPAs (*small circles*). These zones limit commercial activity, to keep ecosystems healthy. The strongest restrictions are no-take (*yellow*), in which all fishing is banned, or low-take (fishing only for local consumption). Some MPAs have weak rules, however (*blue*), or a mix. Scientists say that the world should sequester 30 percent of the seas (*pink*) and that more MPAs should be close to shore where most activity occurs; the 10 largest MPAs make up 68 percent of reserves, and many are in remote waters.



unduly located in areas of economic activity; and from the National Federation of Fishermen’s Organizations, which argued that more scientific evidence was needed for particular sites.

Without a legal requirement to follow the science, the national government caved, according to a recent paper by De Santo. Just 50 of the original 127 MCZ sites have been approved, and they currently lack any management. Every recommended no-take MPA has been scrapped.

Canadian ministers consult scientists when first identifying areas suitable for MPA status, but then they talk to commercial stakeholders behind closed doors. Devillers says he was “shocked” by the rationale used to justify certain commercial activities inside the Laurentian Channel: “Those decisions were not scientifically sound.”

PROTECTION ON THE HIGH SEAS

IN INTERNATIONAL WATERS beyond the exclusive economic zones, the political process of creating MPAs is in its infancy. The high

seas are a free-for-all. Overfishing is rife, and endangered species are caught routinely. Until last year this vast expanse—two thirds of the planet's oceans—lacked a single large MPA. Although a few global laws regulate select activities such as seabed mining, no rules preserve biodiversity. Furthermore, “there’s a lot of connectivity between the high seas and coastal regions,” says Lance Morgan, president of the Marine Conservation Institute, a U.S. nonprofit aimed at securing strong, permanent MPAs.

Improvements could come soon. Last December the first ever large high-seas MPA went into force. It covers 1.55 million square kilometers in Antarctica’s Ross Sea, considered to be one of the least altered ecosystems on earth and home to 16,000 species, including fish, seals, penguins and whales. Some 72 percent of the reserve will be no-take; other sections will allow limited harvesting for scientific research.

Because no international mechanisms exist to create MPAs, the reserve was established by agreement from all members of the Commission for the Conservation of Antarctic Marine Living Resources, which includes the European Union and 24 other countries—the U.S., the U.K., Russia and Australia among them. The deal “is paving the way for other MPAs on the high seas,” Devillers says. He notes that the reserve “is also one of the few examples that we have of a large MPA that is not in tropical waters.”

Ironically, last October the same group failed to agree on creating a similar MPA in East Antarctica. The proposal, rejected for the sixth year running, would protect the region’s krill, cold-water corals and Adélie penguins, which in 2017 suffered a catastrophic failure when only two chicks survived from a breeding colony of about 36,000 adults.

Creating more MPAs will require new treaties. U.N. member states have begun discussing a new law they hope to craft as early as 2019. Skeptics worry that policing extensive areas far out to sea may be difficult, an issue that plagues large national MPAs generally. But satellite technologies are emerging that make monitoring and enforcement easier, an important advance for managing remote reserves such as the one in the Ross Sea.

QUALITY VS. QUANTITY

THE ROSS SEA MPA is also important because it includes specific objectives related to conservation, habitat protection, ecosystem monitoring and fisheries management. As Pressey noted, the size of a reserve is not what matters. Indeed, the discussion among conservationists is slowly moving away from quantity to quality, a message that Devillers was eager to push in his Ottawa testimony. “To reach certain targets, governments had to create large MPAs,” Devillers says. “We’re now trying to push a message to governments that the real challenge is making a difference. It’s the location and the level of protection.”

But where can such science-based insight come from—especially along coastlines that are biologically important but also of interest to industry? One option, Pressey suggests, is that the IUCN represent ocean protection at a global level, above national governments, and provide visionary leadership on where and how MPAs are created.

Even without that mandate, the IUCN could devise clearer definitions of the different levels of protection. Many experts say the MPA label should only apply if a reserve mandates no-take

or carefully controlled low-take. Other areas intended for sustainable use or multiple uses should be renamed, perhaps as “managed areas,” Morgan suggests, which could end the political smoke screen.

The U.N. could also demand that only no-take MPAs can count toward a nation’s 10 percent target for 2020. And it could enforce one of its existing recommendations that nations place at least 10 percent of their coastal waters within strict MPAs rather than drawing all their MPA boundaries far offshore.

Some aquatic scientists, such as Ray Hilborn of the University of Washington, argue that instead of focusing on MPAs, nations should strengthen fisheries management to reduce overfishing, which allows marine food webs to rebound across swaths of ocean without MPA-style rules. But critics say that managing fisheries through common mechanisms such as gear restrictions or seasonal closures does little to preserve entire ecosystems; they note that many of the world’s fisheries are declining despite decades of management.

To spread global cooperation, officials from other countries say the U.S. should finally ratify the Convention on Biological Diversity. That would encourage it to adopt the same criteria for MPAs as every other nation and not the weaker definitions it leans on now. Welch says the move “could instigate the proclamation of new, fully protected and permanent MPAs.”

In the meantime, nations can look to California for ways to make strict MPAs work in busy coastal areas. And despite some glaring weaknesses, the Great Barrier Reef Marine Park has also managed to set no-take zones along certain coasts by allowing commercial use in other, less sensitive areas.

One advantage California has is its wealth, as well as private donors who are willing to fund conservation along with the state. A 2017 analysis of global MPAs published in *Nature* reported that well-staffed MPAs have the best conservation outcomes. Staffing an MPA—for monitoring activities and enforcing rules—costs money. Regions with modest coffers have to be creative. Palau, a Pacific island nation that made 80 percent of its territorial waters a no-take MPA in 2015, used public financing, through crowd-funding, to partly pay for creation and enforcement.

Conservation organizations can play a positive role by highlighting MPAs with good practices. In 2016 the Marine Conservation Institute launched the Global Ocean Refuge System to highlight MPAs that are especially pristine and well managed.

Marine protected areas cannot solve all the oceans’ problems. But if done well, they can help sea creatures by providing refuge out of harm’s way. If MPAs are not doing that, then they may not be useful. “We have to push for protected areas in the ocean until species loss stabilizes,” Devillers says. “That’s the only real metric we can use.” ■

MORE TO EXPLORE

Global Conservation Outcomes Depend on Marine Protected Areas with Five Key Features. Graham J. Edgar et al. in *Nature*, Vol. 506, pages 216–220; February 13, 2014.
Dare to Be Deep: SeaStates Report on North America’s Marine Protected Areas (MPAs). Sabine Jessen et al. Marine Conservation Institute, 2016.
Marine Conservation Institute’s MPAtlas: www.mpatlas.org

FROM OUR ARCHIVES

It’s Time for Ocean Zoning. Tundi Agardy; June 2009.

scientificamerican.com/magazine/sa

The Tribalism of Truth

As political polarization grows, the arguments we have with one another may be shifting our understanding of truth itself

By Matthew Fisher, Joshua Knobe, Brent Strickland and Frank C. Keil

IN A KEY MOMENT OF THE FINAL TRUMP-CLINTON PRESIDENTIAL DEBATE, DONALD TRUMP turned to a question regarding Russian president Vladimir Putin:

“He has no respect for her,” Trump said, pointing at Hillary Clinton. “Putin, from everything I see, has no respect for this person.”

The two debaters then drilled down to try and gain a more nuanced understanding of the difficult policy issues involved. Clinton said,

“Are you suggesting that the aggressive approach I propose would actually fail to deter Russian expansionism?”

To which Trump responded,

“No, I certainly agree that it would deter Russian expansionism; it’s just that it would also serve to destabilize the ...”

Just kidding. That’s not at all what happened. Actually each side aimed to attack and defeat the other. Clinton really said,

“Well, that’s because he’d rather have a puppet as president of the United States.”

To which Trump retorted,

“You’re the puppet!”

IN BRIEF

The existence of moral objectivity is a thorny philosophical question. Cognitive scientists have gathered empirical evidence to see how ordinary people actually think about relativism versus immutable truth.

As political polarization grows, arguing to win is seemingly a more popular style of discourse than arguing to learn, especially in online forums such as Facebook and Twitter.

Researchers have found that the style of discourse people engage in actually changes their understanding of the question itself. If arguing to win is on the rise, it is very likely that objectivism is, too.



Episodes like this one have become such a staple of contemporary political discourse that it is easy to forget how radically different they are from disputes we often have in ordinary life. Consider a couple of friends trying to decide on a restaurant for dinner. One might say, “Let’s try the new Indian restaurant tonight. I haven’t had Indian for months.” To which another replies, “You know, I saw that place is getting poor reviews. Let’s grab some pizza instead?” “Good to know—pizza it is,” says the first. Each comes in with an opinion. They begin a discussion in which each presents an argument, then listens to the other’s argument, and then they both move toward an agreement. This kind of dialogue happens all the time. In our research, which involves cognitive psychology and experimental philosophy, we refer to it as “arguing to learn.”

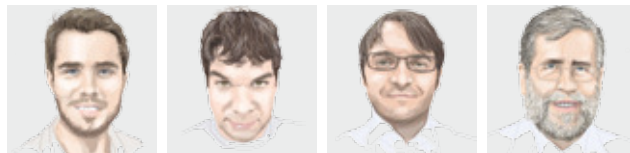
But as political polarization increases in the U.S., the kind of antagonistic exchange exemplified by the Trump-Clinton debate is occurring with increasing frequency—not just among policy makers but among us all. In interactions such as these, people may provide arguments for their views, but neither side is genuinely interested in learning from the other. Instead the real aim is to “score points,” in other words, to defeat the other side in a competitive activity. Conversations on Twitter, Facebook and even YouTube comment sections have become powerful symbols of what the combativeness of political discourse looks like these days. We refer to this kind of discussion as “arguing to win.”

The divergence of Americans’ ideology is accompanied by an animosity for those across the aisle. Recent polls show that partisan liberals and conservatives associate with one another less frequently, have unfavorable views of the opposing party, and would even be unhappy if a family member married someone from the other side. At the same time, the rise of social media has revolutionized how information is consumed—news is often personalized to one’s political preferences. Rival perspectives can be completely shut out from one’s self-created media bubble. Making matters worse, outrage-inducing content is more likely to spread on these platforms, creating a breeding ground for click-bait headlines and fake news. This toxic online environment is very likely driving Americans further apart and fostering unproductive exchanges.

In this time of rising tribalism, an important question has arisen about the psychological effects of arguing to win. What happens in our minds—and to our minds—when we find ourselves conversing in a way that simply aims to defeat an opponent? Our recent research has explored this question using experimental methods, and we have found that the distinction between different modes of argument has some surprisingly far-reaching effects. Not only does it change people’s way of thinking about the debate and the people on the opposing side, but it also has a more fundamental effect on our way of understanding the very issue under discussion.

ARE WE OBJECTIVISTS OR RELATIVISTS?

THE QUESTION OF MORAL and political objectivity is a notoriously thorny one, which philosophers have been debating for millennia. Still, the core of the question is easy enough to grasp by considering a few hypothetical conversations. Consider a debate about a perfectly straightforward question in science or mathematics. Suppose two friends are working together on a problem and find themselves disagreeing about the solution:



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Mary: The cube root of 2,197 is 13.

Susan: No, the cube root of 2,197 is 14.

People observing this conflict might not know which answer is correct. Yet they might be entirely sure that there is a single objectively correct answer. This is not just a matter of opinion—there is a fact of the matter, and anyone who has an alternative view is simply mistaken.

Now consider a different kind of scenario. Suppose these two friends decide to take a break for lunch and find themselves disagreeing about what to put on their bagels:

Mary: Veggie cream cheese is really tasty.

Susan: No, veggie cream cheese is not tasty at all. It is completely disgusting.

In this example, observers might take up another attitude: Even if two people have opposite opinions, it could be that neither is incorrect. It seems that there is no objective truth of the matter.

With that in mind, think about what happens when people debate controversial questions about morally infused political topics. As our two friends are enjoying their lunch, suppose they wade into a heated political chat:

Mary: Abortion is morally wrong and should not be legal.

Susan: No, there is nothing wrong with abortion, and it should be perfectly legal.

The question we grapple with is how to understand this kind of debate. Is it like the math question, where there is an objectively right answer and anyone who says otherwise must be mistaken? Or is it more like a clash over a matter of taste, where there is no single right answer and people can have opposite opinions without either one being wrong?

In recent years work on this topic has expanded beyond the realm of philosophy and into psychology and cognitive science. Instead of relying on the intuitions of professional philosophers, researchers like ourselves have begun gathering empirical evidence to understand how people actually think about these issues. Do people tend to think moral and political questions have objectively correct answers? Or do they have a more relativist view?

On the most basic level, the past decade of research has shown that the answer to this question is that it’s complicated. Some people are more objectivist; others are more relativist. That might seem obvious, but later studies explored the differences between people with these types of thinking. When participants are asked whether they would be willing to share an

apartment with a roommate who holds opposing views on moral or political questions, objectivists are more inclined to say no. When participants are asked to sit down in a room next to a person who has opposing views, objectivists actually sit farther away. As University of Pennsylvania psychologist Geoffrey P. Goodwin once put it, people who hold an objectivist view tend to respond in a more “closed” fashion.

Why might this be? One straightforward possibility is that if you think there is an objectively correct answer, you may be drawn to conclude that everyone who holds the opposite view is simply incorrect and therefore not worth listening to. Thus, people’s view about objective moral truths could shape their approach to interacting with others. This is a plausible hypothesis and one worth investigating in further studies. Yet we thought that there might be more to the story. In particular, we suspected there might be an effect in the opposite direction. Perhaps it’s not just that having objectivist views shapes your interactions with other people; perhaps your interactions with other people can actually shape the degree to which you hold objectivist views.

WINNING VS. LEARNING

TO TEST THIS THEORY, we ran an experiment in which adults engaged in an online political conversation. Each participant logged on to a Web site and indicated his or her positions on a variety of controversial political topics, including abortion and gun rights. They were matched with another participant who held opposing views. The participants then engaged in an online conversation about a topic on which they disagreed.

Half of the participants were encouraged to argue to win. They were told that this would be a highly competitive exchange and that their goal should be to outperform the other person. The result was exactly the kind of communication one sees every day on social media. Here, for example, is a transcript from one of the actual conversations:

P1: I believe 100 percent in a woman’s choice

P2: Abortion should be prohibited because it stops a beating heart

P1: Abortion is the law of the land, the land you live in

P2: The heart beats at 21 days its murder [sic]

The other half of participants were encouraged to argue to learn. They were told that this would be a very cooperative exchange and that they should try to learn as much as they could from their opponent. These conversations tended to have a quite different tone:

P3: I believe abortion is a right all women should possess. I do understand that some people choose to place certain determinants on when and why, but I think it should be for any reason before a certain time point in the pregnancy agreed upon by doctors, so as not to harm the mother.

P4: I believe that life begins at conception (sperm meeting egg), so abortion to me is the equivalent of murder.

P3: I can absolutely see that point. As a biologist, it is obvious from the first cell division that “life” is happening. But I do not think life is advanced enough to warrant abolishing abortion.

It is not all that surprising that these two sets of instructions

led to such results. But would these exchanges in turn lead to different views about the very nature of the question being discussed? After the conversation was over, we asked participants whether they thought there was an objective truth about the topics they had just debated. Strikingly, these 15-minute exchanges actually shifted people’s views. Individuals were more objectivist after arguing to win than they were after arguing to learn. In other words, the social context of the discussion—how people frame the purpose of controversial discourse—actually changed their opinions on the deeply philosophical question about whether there is an objective truth at all.

These results naturally lead to another question that goes beyond what can be addressed through a scientific study. Which of these two modes of argument would be better to adopt when it comes to controversial political topics? At first, the answer seems straightforward. Who could fail to see that there is something deeply important about cooperative dialogue and something fundamentally counterproductive about sheer competition?

Although this simple answer may be right most of the time, there may also be cases in which things are not quite so clear-cut. Suppose we are engaged in a debate with a group of climate science skeptics. We could try to sit down together, listen to the arguments of the skeptics and do our best to learn from everything they have to say. But some might think that this approach is exactly the wrong one. There might not be anything to be gained by remaining open to ideas that contradict scientific consensus. Indeed, agreeing to partake in a cooperative dialogue might be an instance of what journalists call “false balance”—legitimizing an extreme outlier position that should not be weighed equally. Some would say that the best approach in this kind of case is to argue to win.

Of course, our studies cannot directly determine which mode of argument is “best.” And although plenty of evidence suggests that contemporary political discourse is becoming more combative and focused on winning, our findings do not elucidate *why* that change has occurred. Rather they provide an important new piece of information to consider: the mode of argument we engage in actually changes our understanding of the question itself. The more we argue to win, the more we will feel that there is a single objectively correct answer and that all other answers are mistaken. Conversely, the more we argue to learn, the more we will feel that there is no single objective truth and different answers can be equally right. So the next time you are deciding how to enter into an argument on Facebook about the controversial question of the day, remember that you are not just making a choice about how to interact with a person who holds the opposing view. You are also making a decision that will shape the way you—and others—think about whether the question itself has a correct answer. ■

MORE TO EXPLORE

Why Are Some Moral Beliefs Perceived to Be More Objective Than Others?

G. P. Goodwin and J. M. Darley in *Journal of Experimental Social Psychology*, Vol. 48, No. 1, pages 250–256; January 2012.

The Influence of Social Interaction on Intuitions of Objectivity and Subjectivity.

Matthew Fisher et al. in *Cognitive Science*, Vol. 41, No. 4, pages 1119–1134; May 2017.

FROM OUR ARCHIVES

Experimental Philosophy: Thoughts Become the New Lab Rats. Joshua Knobe; November 2011.

scientificamerican.com/magazine/sa





MEDICINE

VANQUISHING Diabetes

Cleaner environments in the industrial world have led to an increase in the incidence of type 1 diabetes. This history shows the way to a novel vaccine

By Kristen M. Drescher and Steven Tracy

Kristen M. Drescher is a professor of medical microbiology and immunology at Creighton University. She studies the role of viruses in autoimmune disease and explores novel therapeutics in treating inflammatory ailments.



Steven Tracy is professor emeritus of pathology and microbiology at the University of Nebraska Medical Center. His research focused on the molecular biology of enteroviruses, as well as on the impact of such pathogens on myocarditis and type 1 diabetes.



ALMOST THREE DECADES AGO A BRITISH EPIDEMIOLOGIST NAMED DAVID P. STRACHAN PROPOSED a simple, if counterintuitive, idea to explain why hay fever, eczema and asthma had become increasingly common over the preceding century. Strachan linked rising rates of these allergic illnesses in the U.K. with improvements in living standards since the industrial revolution—in particular, a sharp drop in the number of infections experienced in early childhood. He surmised that exposure to bacteria and viruses in the first years of life (provided an infant survived them) somehow protected against these conditions showing up later.

Although Strachan's original hunch, now commonly known as the hygiene hypothesis, concerned allergic disorders, researchers have since used its basic tenet—exposure, or lack thereof, to environmental influences—to explain historical increases in various other conditions as well. These include polio-myelitis, multiple sclerosis and type 1 diabetes. Numerous epidemiological surveys have revealed certain escalating disease patterns as industrialization spread from Europe to North America and beyond. Wherever the rate of childhood infections (and mortality) fell, the incidence of several previously rare illnesses started to rise—albeit not uniformly and not all at once.

Major polio outbreaks first began to appear in the late 1800s. The incidence of multiple sclerosis, in which the immune system attacks the protective covering around particular nerve cells, doubled in certain parts of the world in the second half of the 20th century. Type 1 diabetes, which occurs when the body mistakenly destroys cells in the pancreas that make the hormone insulin (which enables the body to use glucose for energy), started creeping up in the first half of the 1900s and rose dramatically in the 1950s.

Exactly how early exposure to various viruses or bacteria can protect against the emergence of a number of seemingly unrelated illnesses remains unclear. Somehow the infections enable the developing body to learn how to deal with pathogens. Further, the absence of exposure to these microbes can prompt the body to attack itself. In particular, a substantial collection of research implicates a fairly large group of pathogens

called enteroviruses in the surge of polio and type 1 diabetes.

Unlike the far more common type 2 diabetes—often tied to weight gain in adulthood—type 1 diabetes usually strikes before the age of 20. Our experiments on mice that are prone to spontaneously acquiring type 1 diabetes has revealed a complex mechanism whereby the same strains of enteroviruses can either prevent or instigate the illness, depending on the age of the mouse when it is infected. Assuming our results are confirmed in humans, a vaccine based on a group of viruses commonly excreted in feces could potentially prevent type 1 diabetes in many individuals.

A CENTURY OF CLUES

OUR RESEARCH BEGAN with a fundamental question, similar to the one Strachan had addressed: Why was type 1 diabetes so rare in the past and yet by the 1950s had become a scourge? In ancient times, Greek, Arab, Indian and Chinese physicians all described a rare cluster of symptoms—including rapid weight loss, abnormal thirst and urine that tasted sweet when sampled—that were almost certainly an outcome of type 1 diabetes. Extrapolating from individual hospital data, researchers calculate that about one or two in every 100,000 children under the age of 15 developed type 1 diabetes in the early 1900s. Today that number is closer to 20 per 100,000 children in parts of the U.S. and more than 60 per 100,000 in Finland. Disturbingly, these numbers continue to rise.

The increase has not been steady, however. After years of just creeping up in some countries, type 1 diabetes began to soar in the middle of the 20th century. Since then, epidemiologists have

IN BRIEF

Unlike type 2 diabetes, the occurrence of type 1 is not linked to diet. It has both a genetic and an environmental origin.

Improved sanitation in the developed world led to historical increases in the incidence of certain diseases, including polio and type 1 diabetes.

Certain viruses commonly found in untreated sewage seem to precipitate and protect against type 1 diabetes, depending on the age at infection.

Vaccines that derive from such viruses may safeguard genetically vulnerable individuals against acquiring type 1 diabetes.

calculated an average annual increase of between 3 and 5 percent across the globe. Between 1998 and 2010 the incidence of type 1 diabetes jumped by a shocking 40 percent.

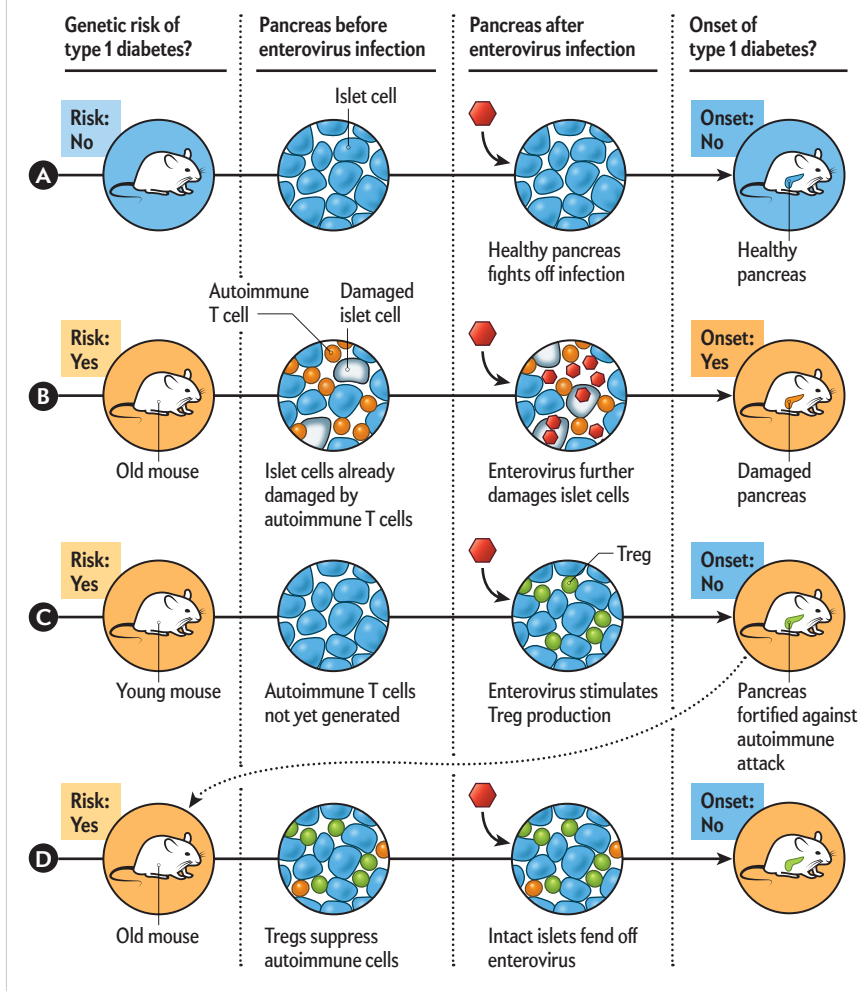
Such a steep rise in such a short time told us that we were not looking at a fundamental change in the human gene pool: DNA does not mutate that rapidly. A variety of different combinations of many genes profoundly increase the risk of an individual acquiring type 1 diabetes. So far as investigators can tell, however, the prevalence of these high-risk genetic profiles has not changed. Instead more and more people with a relatively low genetic predisposition to type 1 diabetes are now suffering from the ailment. Few cases can be linked solely to a genetic disorder. These and other findings, from scientists around the world, strongly suggest that newly emergent environmental factors must be at work.

Various possibilities have been considered over the years—and dismissed. Unlike type 2 diabetes, type 1 does not originate in a person's diet. More intriguingly, several studies have determined that type 1 diabetes occurs more frequently the farther away one gets from the equator. Might a lack of vitamin D, which is easily produced by the body whenever it is in sunlight, account for such regional variation? That idea soon fell apart, however. Epidemiologists discovered, for instance, that some countries in the far north, such as Finland, had higher rates of type 1 diabetes in regions with more sunlight than in regions with less.

The bulk of the evidence points instead to a viral trigger—probably one or more viruses that occur in sewage or in contaminated drinking water. Numerous studies indicate that enteroviruses—so named because they are normally found in the intestine (*énteron* in ancient Greek)—are the culprits. (Indeed, no substantive data link any other kind of viral or environmental influences to the disease.) Some enteroviruses are able to replicate in the pancreas, inflaming areas adjacent to where the islet cells, which produce insulin, reside. The inflamed regions produce autoimmune T cells, which in certain circumstances protect the body against invaders. Autoimmune T cells, however, attack the body's own islet cells, destroying its ability to produce insulin and thereby bringing on diabetes.

Enterovirus Infections and Type 1 Diabetes

A mouse that is free of genetic vulnerability to type 1 diabetes **A** readily fights off an enterovirus infection, and the islet cells in its pancreas continue to produce insulin. How a mouse with genetic predisposition to type 1 diabetes **B**, **C**, **D** responds to an enterovirus infection depends on its age. An older mouse **B** is likely to have its islet cells already damaged by spontaneously generated autoimmune T cells when the enterovirus attacks. In that case, the enterovirus reproduces in the islets, further damages them and reduces the production of insulin—triggering the onset of type 1 diabetes. If, however, the mouse is young, and an autoimmune attack is not yet under way **C**, the infection prompts the production of regulatory T cells (Tregs), which suppress the generation of autoimmune T cells. The Tregs subsequently fortify the pancreas against type 1 diabetes **D**.



Researchers have counted more than 100 types of enteroviruses. No single type of enterovirus, however, seems solely responsible for detonating diabetes around the world. Rather scientists have identified a number of candidates, chief among them six enteroviruses called the Coxsackie B viruses, implicated in the precipitation of the ailment. And they do not understand exactly how such infections might provoke the body to attack itself. The pro-

cess must be complex: epidemiological studies indicate that specific enteroviruses that appear to advance the disorder in some people apparently protect others from developing it in the first place.

DIRTY WATER

AS WE EVALUATED the kinds of experiments that could potentially identify diabetes-causing enteroviruses, we sought clues in a different illness: polio. An often paralyzing childhood affliction, polio is caused by another class of enteroviruses, called polioviruses. These viruses seem to have been around for millennia: an ancient Egyptian stele (a relief carved in a stone slab), now in a Copenhagen museum, appears to depict a polio patient. The terrible condition they engender used to be quite rare, however, until the late 19th century, when sporadic and then annual epidemics suddenly began to occur. Polio killed tens of thousands of children and crippled millions more in the 20th century. As recently as 1988, polio crippled about 1,000 children a day. Thanks to a massive vaccination campaign, polio is now endemic in only three countries.

The hygiene hypothesis helps to explain this sudden surge in polio cases. It is easy to forget that many conveniences of contemporary life in the developed world are only about a century old. Before the widespread installation of municipal water supplies in Europe and North America, people drew water from wells, ponds or public fountains for all purposes, including drinking, bathing and washing clothes. Unsurprisingly, drinking water was often contaminated with human or animal waste. The paucity of running water and soap also meant that people could not be as strict about keeping their hands clean after going to the bathroom as they can be today. Consequently, the simple act of preparing a meal or shaking hands could spread germs far and wide.

Thus, nearly everyone, from early life onward, was exposed to polioviruses that had been passed into the environment from human feces. Newborns did not tend to develop the illness, however, because the mothers had developed immunity against the viruses and passed on protective antibodies to both the developing fetuses during pregnancy and later, while nursing, to their babies. As infants grew older and stopped nursing, and maternal antibodies waned, young children began to make their own protective antibodies against the virus because of repeated exposures to it. So although polioviruses were almost ubiquitous, polio itself was uncommon because youngsters were first protected by the mothers' antibodies and were subsequently protected by their own immune system.

This chain of protection, a part of human life for eons, began to break as human populations entered a "cleaner" world. A boy who might have been spared exposure to polioviruses could encounter them later in life, when he had no protective immunity. Such a chance encounter with poliovirus could then lead to paralytic polio—once in every 100 to 200 poliovirus infections. That is probably why President Franklin D. Roosevelt, for example, developed paralytic polio at the age of 39 while on vacation on an island in New Brunswick, Canada.

Despite polio's grim legacy, we took some consolation from the fact that a vaccine for the viral infection that causes it had proved safe and immensely effective. If researchers can make a vaccine against one type of enterovirus, they should be able to make a vaccine against others as well. And if experiments prove that enteroviruses cause type 1 diabetes, the discovery might point to a potential new treatment: namely, a vaccine against

type 1 diabetes that would protect those at greatest risk from acquiring the viral infection in the first place.

(We can rule out poliovirus as a cause of type 1 diabetes. Although polio epidemics became commonplace in the 20th century, no parallel outbreaks of type 1 diabetes were observed. In addition, polio has been eradicated from countries where the incidence of type 1 diabetes continues to rise.)

To show that a virus causes a particular disease, one should begin by isolating the virus from the affected tissue. For type 1 diabetes, that is the pancreas. But safely sampling tissues from a human pancreas remains a surgical challenge—which is why such biopsies are seldom performed on people who are otherwise healthy. Furthermore, pinning down the exact moment when the body's immune system starts attacking the pancreas and destroying the insulin-producing islet cells is extremely difficult. By the time it becomes clear that someone has type 1 diabetes, any signs of what may have been an active infection have usually disappeared.

Nevertheless, about 40 published reports convincingly link the presence of various enteroviruses to the onset of type 1 diabetes: either the virus or its genetic material was isolated from patients' postmortem pancreatic tissues. And other studies have shown that some kind of enterovirus infection most likely plays a long-term role in the development of type 1 diabetes.

As it happens, a particular strain of mice, known as the non-obese diabetic (NOD) mouse, acquires type 1 diabetes on its own, without any intervention from investigators. (Curiously, NOD mice maintained in hygienic conditions acquire the disease much faster than those in dirty cages.) We hypothesized that NOD mice resemble humans with a genetic predisposition to type 1 diabetes. Furthermore, unlike most enteroviruses, the Cocksackie B viruses replicate well in mice and had already been linked to type 1 diabetes. All these factors made NOD mice the ideal model for exploring the relation between enteroviruses and type 1 diabetes.

In 2002 we deliberately infected very young NOD mice, otherwise held in sterile environments, with Cocksackie B viruses. We found that the animals were much less likely to develop type 1 diabetes as they aged, compared with uninfected control subjects. These results supported the hypothesis that early exposure to microbes offers a protective effect against developing type 1 diabetes. Intriguingly, that effect was not limited to specific types of Cocksackie B viruses, although some seemed to provide stronger protection than others. Experiments by virologist Heikki Hyöty of the University of Tampere in Finland and his colleagues have yielded similar outcomes.

We can think of three possible mechanisms by which exposure to enteroviruses when young might prevent the damaging impact of such infections later in life. First, an infection could trigger the development of protective antibodies against that specific type of enterovirus, so subsequent exposure to the same type would not result in disease. (This process mirrors the principle behind the poliovirus vaccines and many other viral vaccines we use today.) Second, because the Cocksackie B viruses are very similar, on a molecular level, to other enteroviruses, they may prompt the body to more rapidly mobilize adequate defenses, even to enteroviruses it has never encountered before. Third, an enterovirus infection may stimulate the production of regulatory immune cells called Tregs. These generally beneficial cells serve as a conscientious police force, suppressing autoimmune T cells that would otherwise harm the host.

To tease apart these diverse mechanisms, we decided to infect the mice at different ages and observe them for at least 30 weeks after the inoculation. After many years of experimentation, we discovered that infecting older NOD mice with Coxsackie B viruses increased, rather than decreased, their likelihood of developing type 1 diabetes. This finding contrasted sharply with what we had observed in young NOD mice.

We concluded that the pancreas had to be already inflamed—meaning that the insulin-producing islet cells had to be under attack by the mouse's own autoimmune T cells to begin with—for an enterovirus to enter the islets and multiply, accelerating the onset of diabetes. In other words, a genetically induced autoimmune attack on the pancreas had to be under way before a Coxsackie B virus infection could hasten the onset of type 1 diabetes. The older the mouse and the worse the inflammation, the faster the illness would take hold—often resulting in full-blown diabetes in a day or two. (In contrast, older mice held in sterile environments developed diabetes weeks later.)

Studies by immunologist Matthias von Herrath of the La Jolla Institute for Allergy and Immunology in California and his colleagues indicated that enterovirus infections early in life (before an autoimmune attack is launched) can stimulate the production of regulatory T cells, which persist into adulthood. The Tregs suppress the production of autoimmune T cells and thereby protect against type 1 diabetes. But if the pancreas is already inflamed with autoimmune T cells—as would naturally happen in older NOD mice—the virus is able to replicate, damaging the insulin-producing islet cells and precipitating diabetes. In other words, enteroviruses can either protect against or trigger type 1 diabetes in NOD mice, depending on the age at which the infection occurs.

DIABETES VACCINES

ASSUMING THESE OBSERVATIONS in NOD mice reflect what occurs in humans with a genetic predisposition to type 1 diabetes, how might we exploit them to help such vulnerable individuals? Nobody wishes to return to the days of poor or no hygienic practices. But we should not have to. Based on our experience of polio-virus vaccines, we know that developing safe and effective enterovirus vaccines is feasible.


Generally, antiviral vaccines come in three versions: live but attenuated, killed and subunit. Live, attenuated vaccines were originally generated by passing the virus through cells or an animal host to weaken its ability to cause disease. Such vaccines are regarded as the most proficient at inducing immunity because the viruses replicate in the host and induce a normal immune response. But they can mutate rapidly into a pathogenic strain. Genetic engineering now enables specific areas of a virus's genome to be altered or deleted to limit the likelihood of such reversion, but the risk remains. Killed vaccines inactivate viruses so that they cannot multiply, but they still induce a certain level of immunity in the host. Because the virus does not persist in the body, however, periodic revaccination is usually required. A subunit vaccine uses one or more parts of a virus, which are known to stimulate an immune response to produce the desired type of immunity in the person vaccinated.

The bulk of the evidence indicates that no single enterovirus or even a few enteroviruses are involved in the onset of type 1 diabetes throughout the world. Furthermore, the historical evi-

dence indicates that type 1 diabetes was rare when exposure to numerous enteroviruses was a fact of life. We hypothesize, therefore, that vaccinating with multiple types of enteroviruses should offer the most protection. Such an approach would simulate the way humans used to accumulate protective immunity to enteroviruses throughout history. The initial vaccine could be a killed-virus one for safely inducing immunity. Thereafter, either inactivated or highly attenuated vaccines could be used as booster doses.

We find it encouraging that a vaccine approach against type 1 diabetes is finally under way. Hyöty's group is working with Finnish biopharma Vactech Oy, for which Hyöty is chairman of the board, to develop a vaccine against a single type of Coxsackie B virus and has tested its ability to prevent type 1 diabetes in mice. This killed-virus vaccine is expected to be tested for safety in adult humans beginning in 2018. Testing it in children—to ensure safety, generation of a protective immune response to the enterovirus and protection from type 1 diabetes—will take upward of a decade. Given that numerous observations suggest that no single strain of enterovirus is involved with diabetes, we can only remain hopeful that this vaccine will significantly lower the incidence of type 1 diabetes.

In addition, a remarkable variety of efforts are in the works to reverse type 1 diabetes after its onset. Investigator Paolo Fiorina of Boston Children's Hospital and his colleagues have demonstrated that appropriately manipulated stem cells, when infused into mice, can sometimes reverse type 1 diabetes. Another group, led by Denise Faustman of the Massachusetts General Hospital Immunobiology Laboratory, is investigating the efficacy of the bacillus Calmette-Guérin (BCG) vaccine, normally used to prevent tuberculosis, in undoing the effects of type 1 diabetes. Several research groups in the U.S. and the U.K. have focused on immunization with proinsulin (a precursor of insulin) or the DNA that encodes for it. In particular, a 2017 report from a multi-investigator effort by Mark Peakman of King's College London and his colleagues indicates that a protein fragment from proinsulin can induce beneficial responses in people newly diagnosed with type 1 diabetes.

Doctors in the U.S. alone diagnose 40,000 new cases of type 1 diabetes every year. We need to remember that a vaccine cannot entirely eradicate the disease: some cases seem to occur solely because of the patient's genetic makeup. Refining treatments to improve the quality of life for individuals who can no longer make their own insulin remains important. Even if only a small fraction of participants in vaccine trials are protected from the disease, however, a significant number of people will have better lives. Given how fast the incidence of type 1 diabetes is increasing, the ability to make it as rare as it once was could benefit millions. 

MORE TO EXPLORE

Enteroviruses, Hygiene and Type 1 Diabetes: Toward a Preventive Vaccine.

Kristen M. Drescher, Matthias von Herrath and Steven Tracy in *Reviews in Medical Virology*, Vol. 25, No. 1, pages 19–32; January 2015.

FROM OUR ARCHIVES

Operation: Diabetes. Francesco Rubino; July 2017.

scientificamerican.com/magazine/sa

CONSERVATION

GUARDIAN DOGS OF THE MONGOLIAN STEPPE

An American entrepreneur is working to convert Mongolian herders into conservationists by reintroducing the region's traditional livestock protection dog

By Jason Overdorf

Photographs by Soyolbold Sergelen





Jason Overdorf is a freelance writer based in New Delhi, India.



TWO DAYS' DRIVE FROM THE MONGOLIAN capital of Ulaanbaatar, 100 miles from the country's border with China, the foothills of the Altai Mountains slash a jagged brown line across the scrubby southern Gobi grasslands. Home to hungry wolves and snow leopards and brutal winters, it is rough country for herders such as 57-year-old Otgonbayar, a weather-beaten nomad who works his flock of 1,000-odd cashmere goats and two dozen sheep from the back of a 100-cc Chinese motorcycle.

"The wolves were terrible this winter," Otgonbayar says on a spring day in 2016, as his wife passes around a dented aluminum bowl filled with Russian candies and sugar cubes. "If it weren't for my dog, my losses would have been much greater." Just a few days earlier wolves had killed four of his animals. In a typical season, they can take 50 or more.

Since the 1990s, to compensate for the animals lost to predators and inclement weather, herders such as Otgonbayar have vastly increased the size of their flocks, which has led to overgrazing that has plunged the steppe into a vicious cycle of herd expansion and environmental degradation. Now, however, an American biologist-turned-entrepreneur named Bruce Elfström is working with the herders to break that pattern by reintroducing a tool developed thousands of years ago: an indigenous livestock guardian dog known as the bankhar. "The idea was to find the dogs of old, their grandfathers' dogs, then breed them and give them back to the people. The goal being that without the fear of predators, they won't raise so many goats, which are turning the steppe into desert," Elfström says.

COLLECTIVE FAILURE

BEFORE MONGOLIA ABANDONED COMMUNISM in the 1990s, socialist controls dictated how many animals herders could raise. Regulations prevented overgrazing through a system of rotating pas-

1



tures, and the government made sure herders in remote grasslands could get their meat and wool to market. During the country's transition to a market economy, that scheme was dismantled. The government privatized the herds, but the pastures remained common land. That arrangement encouraged herders to raise more animals without providing any incentive to preserve the range. At the same time, the rise of neighboring China resulted in soaring demand for cashmere, explains Zara Morris-Trainor, a doctoral candidate at the University of Aberdeen in Scotland, who is studying the impact of the trade on Mongolia's snow leopards.

IN BRIEF

Predators and climate change have driven goat herders in Mongolia to boost the size of their flocks, which has led to overgrazing of the grassland.

A program to reintroduce the region's traditional livestock guardian dog aims to deter predators and thus encourage herders to reduce herd sizes.

Thus far the dogs seem to be highly effective at preventing livestock losses. But finding suitable families to adopt them has proved challenging.



BRINGING BACK BANKHARS, the indigenous livestock guardian dogs of Mongolia (1), could reduce losses of goats to snow leopards and wolves and so help protect these imperiled predators and the steppe (2).

The collapse of the Soviet Union in 1991—which resulted in a precipitous drop in bilateral trade with Russia—made Mongolia more dependent on China. Almost overnight, nomads who had traditionally raised a mixed herd of camels, goats, horses, sheep, cattle and yaks began ramping up herd sizes with more and more cashmere-producing goats, which are harder on the soil because their sharp hooves puncture the biological crust that prevents wind erosion. Historically accounting for less than a fifth of all livestock, goats made up about a third of some 29 million domesticated grazers by 1996. By 2015 the goat population had surged to nearly 24 million out of a total herd of 56 million livestock.

The expansion of Mongolia's desert has kept pace with that increase. Since 1996, which was also the year in which the country first joined the United Nations Convention to Combat Desertification, the amount of its land severely impacted by desertification has more than tripled to around 100,000 square miles—about a sixth of Mongolia's total land mass. As much as 80 percent of the damage is the result of overgrazing, researchers at

Oregon State University concluded from satellite maps of the vegetation in 2013.

Over roughly the same period, uncontrolled hunting and habitat destruction have killed 75 to 90 percent of various prey animals. Their downfall has forced wolves and snow leopards to target the nomads' herds, even as ever more frequent winter storms known as *dzuds* have periodically killed millions of livestock. Without other adequate forms of insurance, the nomads have taken matters into their own hands: in good times, they have enlarged their herds in hopes of ending up with at least some animals in the spring; in lean times, they have confined their livestock in smaller areas to try to protect them. Both responses have intensified the problem of desertification.

Making matters worse, because the herders are impotent against drought, snow and climate change, many of them focus their resentment on predators. Reliable statistics about how many animals they kill are hard to come by. But as many as 14 percent of Mongolian herders interviewed for a 2002 study

admitted to killing snow leopards in retribution for dead livestock. And experts still cite retaliatory killings as among the main threats to the big cats, according to Bayarjargal Agvaantseren, director for the Snow Leopard Trust's partner organization in Mongolia. Wolves are in the crosshairs, too. "For wolves, there is still local-government-level hunting organized annually in some areas," Agvaantseren says. Conservationists fear for the future of both species in Mongolia.

RESCUE DOGS

ELFSTRÖM BELIEVES he can help. In 2013 he designed a program to reduce livestock losses—and thereby encourage support for wildlife conservation—by bringing back the bankhar, a large, black-and-brown mountain dog. The Mongolian Bankhar Dog Project has set up a breeding and training center near Ulaanbaatar and placed the dogs with nomads who face high pressure from predators. Otgonbayar is one of the first participants. "The goal is to take what we're doing and hand it off to Mongolians so we can have satellite breeding centers around the country," says the 51-year-old Elfström, who owns a Connecticut-based off-road driving school called Overland Experts.

Bankhars were once ubiquitous on the Mongolian steppe. In a nod to their fearsome nature, the traditional Mongolian greeting is "Hold your dog." Dogs are the only animals the Mongolians believe to be worth naming. Various defining myths and folktales—including the origin myth that traces the birth of Genghis Khan to the coupling of a blue wolf and a fallow deer—confirm that traditionally nomads believed that the Mongolians and their dogs were "of the same bones," notes anthropologist Gaby Bamana, currently a visiting scholar at the University of Groningen in the Netherlands.

Despite their cultural importance, however, true bankhars have mostly disappeared since the communist era. A symbol of independence, fierce, territorial dogs were unsuited to the ideology of the times and the practical realities of state-owned herds, which allowed herders to keep only seven animals per person as private property. There was even a brief craze for bankhar fur coats in Moscow in the 1930s. Furthermore, crossbreeding between bankhars and other dogs, including an influx of German shepherds that accompanied the effort to build the Trans-Siberian Railroad in the 1940s and the guard dogs and household pets of more than 100,000 Russian military personnel who moved to Mongolia in the 1960s, has diluted the gene pool of the indigenous bankhar population. Indeed, it is hard to find bankhars that have not been crossed with foreign breeds, which can reduce their effectiveness as livestock protectors by reintroducing predatory traits that breeders promote in dogs like the German shepherd.

The expertise required to raise effective bankhars is also in short supply. The same collectivization programs that discouraged their use resulted in the loss of much traditional knowledge. Few of the herders whose families have occupied the steppe for generations now remember how to rear dogs to protect livestock.

Why, then, is Elfström intent on reviving the bankhar? Guard-

ian dogs are still common elsewhere in the world, from the ovcharka in the Caucasus to the Anatolian shepherd in Turkey to the Great Pyrenees in the West. Why not just import these breeds to Mongolia?

One reason is biological. Like the forebears of other guardian dogs, the bankhar was not created through the kind of careful inbreeding that resulted in modern breeds such as the Great Dane or golden retriever. Rather it evolved through a combination of natural and artificial selection: the best specimens thrived, whereas the nomads did not feed useless ones and culled those that chased or killed livestock. The result is a dog that is purpose-built for guarding flocks under harsh conditions.

Standing between 26 and 33 inches tall at the shoulder and weighing 80 to 125 pounds, bankhars are remarkably well

The bankhar is remarkably well adapted to the challenges of the steppe, where temperatures can soar to 100 degrees Fahrenheit in summer and plunge to 50 below zero in winter.

adapted to the challenges of the steppe, where temperatures can soar to 100 degrees Fahrenheit in summer and plunge to 50 below zero in winter. Their thick, shaggy fur, which feels almost as fine as cashmere to the touch, features a heavy undercoat that protects them from the cold in the winter and is shed in the summer, when they sometimes dig underground dens to escape the heat. Bankhars also need less food than other livestock guardian dogs of similar size—perhaps because they have evolved a slower metabolism, Elfström suggests—an important consideration in a region where many families have little to spare.

But cultural reasons, rather than biological ones, ultimately prompted Elfström to settle on reintroducing the bankhar instead of importing a similar guardian dog such as the ovcharka, which thrives in extreme climates elsewhere in Central Asia. Decades of Soviet meddling have left Mongolians wary of foreign advisers, and herders are especially skeptical that a bunch of Americans who do not seem to know a goat from a sheep will have anything to teach them. The bankhar, however, still has great cultural significance: traditionalists are convinced that the revered dogs can see into the spirit world, and more modern herders view them as a powerful symbol of national pride. "Everybody wants a bankhar," Elfström says. If he can forge a relationship with the herders through the bankhar program, perhaps they will be amenable to other conservation efforts.

UPS AND DOWNS

THUS FAR ELFSTRÖM AND HIS TEAM have bred and distributed more than 60 bankhar puppies to herders. Although the project is in

its early stages, a detailed study of its impact is now under way, and Elfström says he has “firm data” showing a 90 to 95 percent drop in the livestock killed by predators. The scheme has attracted the interest of nonprofit groups, including the Snow Leopard Trust and the Wildlife Conservation Society (WCS). In 2016 the WCS helped to place six dogs with three families in an area of the Gobi that sees a lot of predation from wolves and raptors, according to Onon Bayasgalan, a conservationist who works with the WCS in Mongolia. “If the bankhar initiative proves to be a success with these herder families, we will consider expanding the number of families receiving the dogs. In the future, we may also consider collaborating with the bankhar project in our other project sites,” Bayasgalan said in 2016. This year Elfström is supplying the WCS with another 10 to 14 dogs.

Conservationists hope that by reducing stock losses, the dogs can help generate support for other ambitions, such as “sustainable cashmere,” which requires that the nomads focus on smaller herds to produce high-quality wool that they can sell for a higher price than regular wool. Already the distribution of puppies is acting as an informal reward for model herders such as Otgonbayar, whose rangeland is near a protected area for snow leopards. Elfström himself aims to institute further incentives to encourage herders to refrain from killing predators once he has shown how effective the dogs can be at deterring them.

That said, he has run into several hurdles. In May 2016 Mongolian environmental regulations forced him to shift his breeding center to a new location near Hustai National Park in the north of the country, thereby prompting a reboot of the project. Because of an accident, the faithful four-wheel-drive van that the team used to transport dogs and equipment now needs to be replaced. And although herders covet the bankhars, it is a constant struggle to find ones who are willing to implement the training protocol necessary to raise the puppies to be effective working dogs. The regimen, which requires keeping the puppies corralled with the livestock from the age of six to 13 weeks so that they bond to the goats and sheep the way pet dogs do to humans, is not complicated, but it requires a herder who is willing to listen.

More discouraging, the collaboration with the Snow Leopard Trust has stalled. A little headway has been made, but Gustaf Samelius, assistant director of science for the trust, says it is not actively working to place dogs from Elfström’s bankhar project because all the nomads in the areas where the organization works already have dogs of their own. “From the few people I’ve talked to, they all seem to be happy with the dogs they have,” Samelius says.

That claim is a major source of frustration for Elfström. Virtually without exception, the dogs in question are strays or crossbreeds that were not raised to bond with the herders’ livestock, he says. They provide some deterrent against predators, mostly by barking if a snow leopard comes near the corral at night, but they cannot be trusted to guard the herd in the pasture because they are bonded to the family rather than its livestock. They are more likely to follow the shepherd back to the yurt than to keep watch over the flock.

Despite Samelius’s assertion that nobody wants them, the bankhar team is working on its own to place pups with families who live in the same areas where the Snow Leopard Trust is

active, though perhaps not the same families who say they are satisfied with their current dogs. Herders sometimes call their untrained crossbreeds bankhar out of ego or loyalty. But when they are offered a true, working bankhar from the breeding project, “all of a sudden, their dog becomes a mix, and they want ours,” Elfström says.

“Many people, including scientists, are still of the mindset that ‘a dog is a dog,’ despite an overwhelming glut of papers and data to prove them wrong,” Elfström says. “Herders know bankhars are not just dogs.” Research has shown that similar livestock guardian dogs have had dramatic impacts in Africa, Australia, Europe and the western U.S., where breeds such as the Great Pyrenees and Anatolian shepherd have reduced or eliminated livestock losses to cheetahs, coyotes, dingoes, foxes, bears and wolves. In Namibia the introduction of some 450 Anatolian shepherds over the past 20 years virtually eliminated livestock predation by cheetahs, helping to convince farmers to stop killing as many as 1,000 big cats a year. In Mongolia, where wildlife conservation is in its infancy, the effect could be equally dramatic, Elfström believes.

Provided the project succeeds in breeding enough dogs and in convincing enough nomads to rear them the right way, a reduction in retribution killings is likely. Other successful livestock guardian dog programs, including Cheetah Outreach in South Africa, have convinced farmers to sign contracts agreeing to not kill predators, leading to a sharp decline in retribution killings. And evidence from a livestock vaccination program run by the Snow Leopard Trust in Pakistan suggests that reducing livestock losses can encourage farmers to raise fewer animals: the program helped to reduce herd sizes by 17 percent.

But even if Elfström does succeed in persuading people to limit the size of their flocks, changing the practices of a few herders will be merely a Band-Aid on the proverbial bullet hole, he realizes, unless it is accompanied by a raft of other nonprofit efforts and policy measures aimed at conserving the Mongolian steppe and its denizens. Luckily, many such programs are already under way. Ulaanbaatar-based Sor Cashmere, for instance, is working to popularize cashmere made from the hair of yaks and camels, which are less environmentally damaging than goats. The Wildlife Conservation Society, for its part, is working with herders, mining companies and other stakeholders to fund ecological mitigation projects and promote sustainable goat cashmere.

“What we want to see is the herders moving more. What we want to see is them having a diverse herd. What we want to see is them not having extra animals to counter the fact that they’re going to lose so many,” Elfström says. “But that requires that we work with other nongovernmental organizations. We can’t do everything.” ■

MORE TO EXPLORE

Dogs and Herders: Mythical Kinship, Spiritual Analogy, and Sociality in Rural Mongolia. Gaby Bamana. *Sino-Platonic Papers*, No. 245. Edited by Victor H. Mair. University of Pennsylvania, March 2014.
Mongolian Bankhar Dog Project: www.bankhar.org

FROM OUR ARCHIVES

[From Wolf to Dog](#). Virginia Morell; July 2015.

scientificamerican.com/magazine/sa

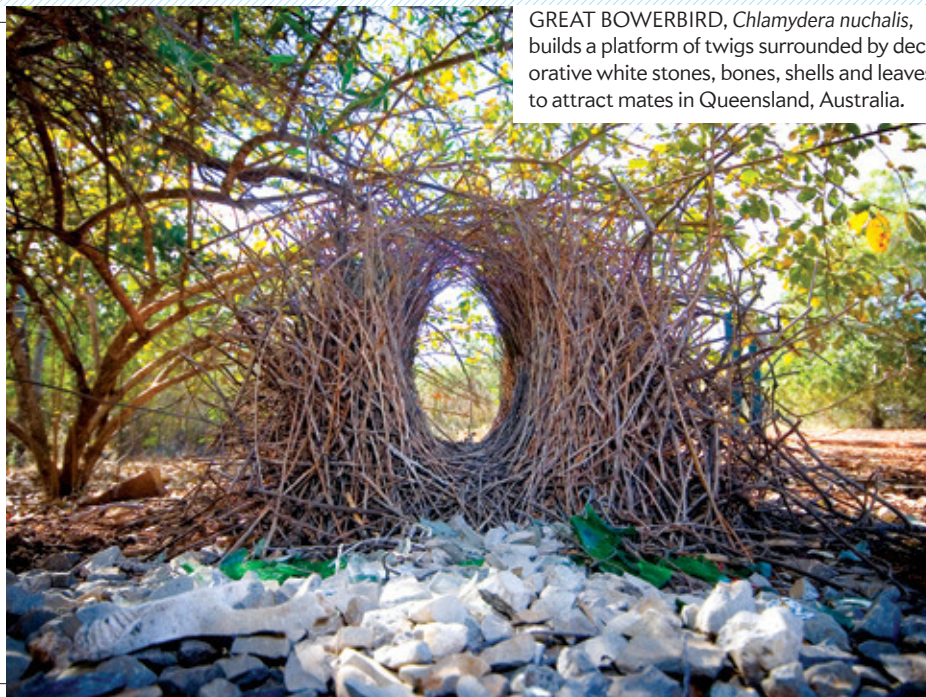
RECOMMENDED

By Andrea Gawrylewski

A Taste for the Beautiful:

The Evolution of Attraction

by Michael J. Ryan.
Princeton University Press,
2018 (\$29.95)



GREAT BOWERBIRD, *Chlamydera nuchalis*, builds a platform of twigs surrounded by decorative white stones, bones, shells and leaves to attract mates in Queensland, Australia.

If a female **túngara frog** doesn't fancy the call of a singing male, she moves on to another suitor or may give him a body slam. A male bowerbird builds large huts from sticks and decorates them, sometimes even using berry juice as wall paint. Humans buy showy cars, bathe in perfume and pour money into elaborate beauty routines. Mating is the end goal of most of these bizarre efforts to attract, but what defines which colors in plumage, which notes of birdsong or which facial features prove alluring? Zoologist Ryan charms readers with his account of attraction in the animal kingdom, including humans. As he puts it, beauty is in the "brain of the beholder."

—Yasemin Saplakoglu

The Spinning Magnet: The Electromagnetic Force That Created the Modern World—And Could Destroy It
by Alanna Mitchell. Dutton, 2018 (\$28)



In a patch of the Atlantic Ocean between Africa and South America, the earth's magnetic field runs opposite to its normal direction. And

this patch might be a harbinger of things to come. Our planet's magnetic field has flipped directions hundreds of times in its history, the north and south magnetic poles swapping locations, and some scientists think we are overdue for another switch, explains science journalist Mitchell. She details the evidence building up and canvases the fascinating history of the study of the earth's magnetic field. If another pole swap is coming, the process could prove catastrophic for life, disrupting animals' magnetic navigation and letting in harmful space particles that could fry organic cells and electronic circuits alike. —Clara Moskowitz

A Wilder Time: Notes from a Geologist at the Edge of the Greenland Ice
by William E. Glassley. Bellevue Literary Press, 2018 (\$17.99)



The jagged and intricate coastline of Greenland, with its thousands of fjords, islands and skerries, measures longer than the circumference of the

planet. But the geologic origin of the landscape remains controversial. Over the course of several field trips to this wilderness, geologist Glassley and two colleagues went in search of evidence that the land is in fact the remnant of an ancient mountain chain and the site of tremendous geologic upheaval. In this nonlinear telling of those travels, Glassley ponders the nature of perception and the human mind, describes the dramatic physical features of Greenland's makeup and recounts the thrilling adventures of his extended visits there: "Wandering alone in that infinite, ancient wilderness ... that, to me, was heaven."

Close Encounters with Humankind: A Paleanthropologist Investigates Our Evolving Species
by Sang-Hee Lee. W. W. Norton, 2018 (\$26.95)



Although we may marvel at our unique human attributes, the biological details of hominin evolution can seem convoluted and dry. Paleanthropologist Lee quickly discovered this when she first began teaching undergraduate classes at the University of California, Riverside—she was often met with a general lack of interest. Years later Lee was contacted out of the blue by a journalist from her home country of South Korea and asked to write a series of columns about human evolution for a broad readership. Her articles became popular, and Lee started teaching her students in the same way she was telling stories to the Korean audience. This book is a collection of those stories—short tidbits that answer intriguing questions of evolution, from why we eat meat to where back pain comes from.

AUSCAPE Getty Images



Michael Shermer is publisher of *Skeptic* magazine (www.skeptic.com) and a Presidential Fellow at Chapman University. His new book is *Heavens on Earth: The Scientific Search for the Afterlife, Immortality, and Utopia* (Henry Holt, 2018). Follow him on Twitter @michaelshermer

Alvy's Error and the Meaning of Life

Science reveals our deepest purpose

By Michael Shermer

In a flashback scene in the 1977 film *Annie Hall*, Woody Allen's character Alvy Singer is a depressed young boy who won't do his homework because, as he explains to his doctor: "The universe is expanding.... Well, the universe is everything, and if it's expanding, someday it will break apart, and that will be the end of everything." His exasperated mother upbraids the youth: "What has the universe got to do with it? You're here in Brooklyn. Brooklyn is not expanding!"

Call it "Alvy's Error": *assessing the purpose of something at the wrong level of analysis*. The level at which we should assess our actions is the human timescale of days, weeks, months and years—our life span of four-score plus or minus 10—not the billions of years of the cosmic calendar. It is a mistake made by theologians when arguing that without a source external to our world to vouchsafe morality and meaning, nothing really matters.

One of the most prominent theologians of our time, William Lane Craig, committed Alvy's Error in a 2009 debate at Columbia University with Yale University philosopher Shelly Kagan when he pronounced: "On a naturalistic worldview, everything is ultimately destined to destruction in the heat death of the universe. As the universe expands, it grows colder and colder as its energy is used up. Eventually all the stars will burn out, all matter will collapse into dead stars and black holes, there will be no life, no heat, no light—only the corpses of dead stars and galaxies expanding into endless darkness. In light of that end, it's hard for me to understand how our moral choices have any sort of significance. There's no moral accountability. The universe is neither better nor worse for what we do. Our moral lives become vacuous because they don't have that kind of cosmic significance."

Kagan properly nailed Craig, referencing the latter's example of godless torturers: "This strikes me as an outrageous thing

to suggest. *It doesn't really matter?* Surely it matters to the torture victims whether they're being tortured. It doesn't require that this make some cosmic difference to the eternal significance of the universe for it to matter whether a human being is tortured. It matters to *them*, it matters to their *family*, and it matters to *us*."

Craig committed a related mistake when he argued that "without God there are no objective moral values, moral duties or moral accountability" and that "if life ends at the grave, then ultimately it makes no difference whether you live as a Stalin or a Mother Teresa." Call this "Craig's Categorical Error": *assessing the value of something by the wrong category of criteria*. In my new book, recently published, *Heavens on Earth*, I debunk the common belief that without God and the promise of an afterlife, this life has no morality or meaning. We live in the here and now, not the hereafter, so our actions must be judged according to the criteria of this category, whether or not the

category of a God-granted hereafter exists.

Whether you behave like a Soviet dictator who murdered tens of millions of people or a Roman Catholic missionary who tended to the poor matters very much to the victims of totalitarianism and poverty. Why does it matter? Because we are sentient beings designed by evolution to survive and flourish in the teeth of entropy and death. The second law of thermodynamics (entropy) is the first law of life. If you do nothing, entropy will take its course, and you

will move toward a higher state of disorder that ends in death. So our most basic purpose in life is to combat entropy by doing something "extropic"—expending energy to survive and flourish. Being kind and helping others has been one successful strategy, and punishing Paleolithic Stalins was another, and from these actions, we evolved morality. In this sense, evolution bestowed on us a moral and purpose-driven life by dint of the laws of nature. We do not need any source higher than that to find meaning or morality.

In the long run, entropy will spell the end of everything in the universe and the universe itself, but we don't live in the long run. We live now. We live in Brooklyn, so doing our homework matters. And so, too, does doing our duty to ourselves, our loved ones, our community, our species and our planet. ■

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Steve Mirsky has been writing the Anti Gravity column since a typical tectonic plate was about 36 inches from its current location. He also hosts the *Scientific American* podcast Science Talk.



Bee Sides

A surprising number of animals exhibit handedness—bees included

By Steve Mirsky

I'm right-handed. This fact makes it easier for me than for lefties to push revolving doors and play the accordion, though not at the same time. Our societal infrastructure is set up for righties, the result of (or perhaps a continuing cause for) only about 10 percent of humanity being left-handed.

It's actually the brain's infrastructure that seems to be mostly responsible for almost all of us being righties. A 2009 paper in *Philosophical Transactions of the Royal Society B* notes: "Lateralization of brain and behaviour refers to the fact that the hemispheres of the brain differentially control behaviour.... At the behavioural level, it is often expressed in side biases for motor output, perception and information processing."

Chimps show a slight tendency toward right-sidedness but much less than our 9:1 ratio. Horses can have a preferred side, which is complicated by that pesky extra set of legs in the back. A 2016 article in the publication *The Northwest Horse Source* explains that most mounts are "'right front-left hind horses.' They generally are a little more comfortable ... turning to the left." (You know what you call a Thoroughbred that doesn't like

to turn left? A loser. In the U.S. anyway, where races are counterclockwise.)

A 2015 study in *Current Biology* looked at seven marsupial species and found that the ones that walked on all fours lacked a conspicuous sidedness. But the bipedal bouncers, such as kangaroos and to a lesser extent wallabies, did have a preference—and they're mostly lefties. (Listen, it's Australia. The fact that a large, upright, hopping, pouch-bearing herbivore happens to be predominantly left-handed is unremarkable when you consider that in 1932 the Royal Australian Artillery lost a war against emus. Flightless birds. Search online for "The Great Emu War" if you think I'm lying.)

Despite all these examples of laterality, it still came as a surprise last November when a study found that some bees exhibited handedness when they had to run an obstacle course. By "run" I mean "fly," and by "handedness" I mean what the authors of the paper in the journal *PLOS ONE* meant when they entitled it "Obstacle Traversal and Route Choice in Flying Honeybees: Evidence for Individual Handedness."

Actually the new study cited a 2001 paper in the *Journal of Insect Behavior* that found that "foraging bumblebees display handedness and tend to rotate in the same direction on successive inflorescences." So we already knew that bumblebees exhibited a sidedness when they landed on flowers. Now we know they're sided when they fly, too. (Honeybees are also excellent dancers.)

For this study, researchers coerced 102 bees to fly together through a tunnel to get to a sucrose solution, much like how you have to negotiate a hotel corridor to get to the soda machine. Except that at the halfway mark of the bee's tunnel was a barrier with two holes in it. Should your hotel corridor include a barrier with holes in it, go back to your room and strongly consider moving to another hotel.

When the two holes were the same size, about half the bees went through each hole. When one hole was bigger than the other, more bees used the bigger hole. But some flying bees stood their ground. For example, when the smaller hole was on the right side of the barrier, a truly committed righty would even land and wait to walk through the smaller hole rather than use the bigger opposite-side opening, much as a truly committed lefty still thinks Bernie would have won.

The researchers interpreted the results laterally and found that about 45 percent of the bees had a side preference, split evenly between right and left. The distribution of sidedness may help a colony fly efficiently through dense foliage—that some members insist on using smaller gaps could put an upper size limit on the group using the larger space. Thus keeping them from bumbling. ■

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FEBRUARY

1968 Nuclear Economics

"Nuclear power, like the boy next door, seems to have grown up overnight. That it has indeed come of age is incontrovertible. For two years running it has accounted for nearly half of all the new power-generating capacity ordered by U.S. utilities. That maturity came quickly is also incontrovertible. The first truly large-scale nuclear unit—a 428,000-kilowatt installation at San Onofre, Calif.—was licensed for construction as recently as February 24, 1964, and announcements of commercial nuclear power projects did not begin to gain momentum until the fall of 1965; yet by the summer of 1966 nuclear power had drawn abreast of fossil power in the utility marketplace. It is safe to say that no one, not even the most optimistic reactor manufacturer, expected so rapid or decisive a market breakthrough."

1918 Auto Export Superpower

"The United States is at present the world's market for motor cars and trucks. An agent for the U.S. Bureau of Foreign and Domestic Commerce reports a prosperous condition of affairs prevailing in Japan, which is buying more automobiles, especially large cars, than ever before. There are about 2,400 automobiles in Japan at present, 600 of which were imported during the first nine months of last year, as against 218 during all of 1916. Japanese roads are very narrow and the bridges weak, but the Government is spending \$2,000,000 on the road from Tokio to Yokohama, and has ordered the provinces to improve their roads and bridges."

High Heels

"Unfortunately the fashion which calls for ever higher heels is as

unhygienic as it is unesthetic. By means of the motion picture camera Dr. Édouard Quénu has been able to analyze the constrained gait which results from a heel three inches or more in height. In the film, the subject passes before us in short, jerky steps, moving her foot through the air and putting it on and off the ground quite rigidly, without change of relative position of heel and toe, giving the effect of a stiff and awkward glide rather than a step. It is the jerky progress of an automatic puppet which we have here, not the supple gait worthy of a brisk human being."

War Balloons

"The French navy is employing a number of kite balloons with tenders for the purpose of spotting German U-boats lurking near the coast and at the entrances of important harbors. The life of a



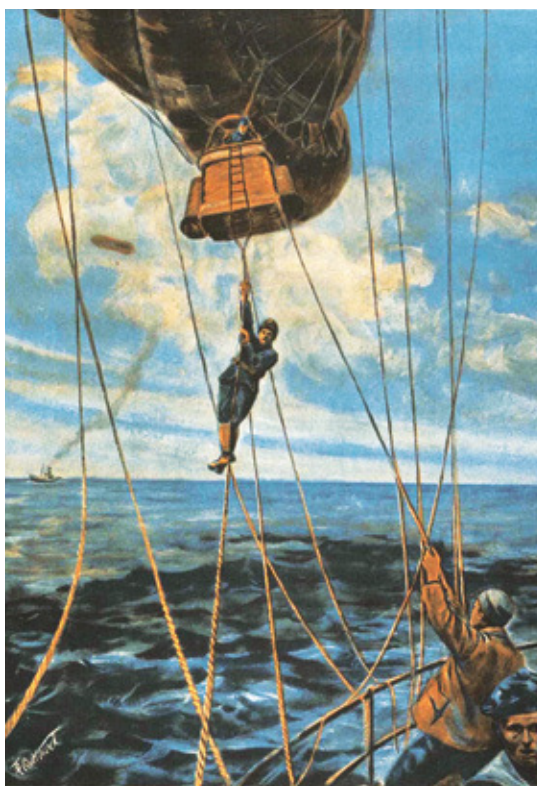
1968



1918



1868



1918: A French aerialist needed to be nimble to climb into the basket of a kite balloon to look for enemy submarines.

kite observer at sea is full of thrills, especially during those times when he climbs up to the balloon swinging above the trawler [see illustration]. It is said of these kite observers that some of their feats in this connection would compare most favorably with those of a trained tight-rope walker."

1868 Explosive Argument

"An inquest has been held in the latest nitro-glycerin disaster, the explosion at Newcastle, England. The inventor of 'blasting oil,' Mr. Alfred Nobel, of Hamburg, writing to the London *Times* relative to the same Newcastle accident, bitterly complains that the introduction of this valuable explosive, owing to the accidents resulting from gross carelessness, has been systematically opposed. The Newcastle explosion, it seems clear, was caused by the grossest violation of the printed instructions. The cans containing the nitro-glycerin were opened with blows of a spade, and then thrown into a hole one upon another. From the shock thus occasioned the explosion took place."

A Strict Home

"The *New England Farmer*, published in Boston, contains every week sensible hints for family rule and life: 'Don't be afraid of a little fun at home, good people! Don't shut up your house lest the sun should fade your carpets and your hearts; lest a hearty laugh shake down some of the musty old cobwebs there. When once a home is regarded as only a place to eat, drink, and sleep in, the work is begun that ends in gambling houses and reckless degradation. Young people must have fun and relaxation somewhere; if they do not find it at their own hearthstones, it will be sought at other and perhaps less profitable places.'"

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SPEAKERS:



Ron Martin, Ph.D.

Ron Martin, Ph.D. is Professor of Geological Sciences at the University of Delaware. He grew up in southwestern Ohio, where world famous fossil assemblages drew his attention to paleontology and Earth history. He received a B.S. degree in geology from Bowling Green State University (Ohio), M.S. in Geology from the University of Florida, and the Ph.D. in Zoology from the University of California at Berkeley, specializing in protozoology. He worked as an operations micropaleontologist and biostratigrapher for Unocal in Houston, Texas from 1981–1985 before coming to the University of Delaware. He teaches introductory courses in physical geology and Earth history, paleontology, paleoecology, sedimentology and stratigraphy, and Advanced (Sequence) Stratigraphy, and has been nominated several times for the univer-

sity-wide Best Teacher Award. His research interests include the taphonomy (processes of formation and preservation) of microfossil assemblages and, most recently, the role of phytoplankton evolution in the diversification of the marine biosphere. He is the author or co-author of more than 60 papers and of the books *One Long Experiment: Scale and Process in Earth History* (Columbia University Press) and *Taphonomy: A Process Approach* (Cambridge University Press) and edited *Environmental Micropaleontology: The Application of Microfossils to Environmental Geology* (Kluwer/Plenum Press).



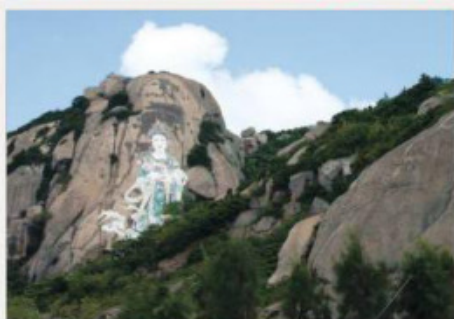
Andrew Wilson, Ph.D.

Dr. Andrew R. Wilson is Professor of Strategy and Policy at the United States Naval War College in Newport, RI, the world's oldest and most prestigious center for senior military education. An old "China Hand," Andrew received his Bachelor of Arts in East Asian Stud-

ies from the University of California, Santa Barbara, and earned a Ph.D. in History and East Asian Languages from Harvard University with a specialization in the history of Pre-Modern and Modern China. His dissertation dealt with the Chinese merchant community in the Colonial Philippines.

Professor Wilson has published numerous articles and books on Chinese maritime history, the Chinese diaspora, Chinese military history and the history of maritime East Asia. Professor Wilson's research interests are not limited to history. He has also written on Chinese strategic culture, contemporary Asian security, Chinese politics and Chinese military modernization. In addition, he is an expert on strategic thought and formerly served as the Naval War College's Philip A. Crowl Professor of Comparative Strategy.

Professor Wilson's books include *Ambition and Identity: Chinese Merchant-Elites in Colonial Manila, 1885–1916*; *The Chinese in the Caribbean*; *China's Future Nuclear Submarine Force*; and the forthcoming *The Acme of Skill: Strategic Theory from Antiquity to the Information Age*.



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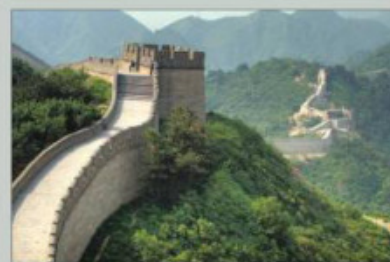
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| 23-Oct | Beijing to Xi'an: | Beijing leisure time, airport transfer, fly to Xi'an
Sofitel Legend Hotel |
| 24-Oct | Xi'an: | Terracotta Warriors, Great Mosque, and City Wall |
- 

This is no ordinary visit to Pit #1, the major archaeological site at the Terracotta Warriors Museum. You'll have special access and walk next to and between the warriors behind the scenes at the "hospital", where ~ 200 repaired warriors stand in formation. In the restoration room at the Research Center, learn about the tools and methods used to conserve and repair the antiquities. In this restricted area, you'll see special pieces not on display in the main pits of the Museum.

Handle priceless ancient ceramics with distinguished collector Mr. Jingwen Ren at the Xi'an Ox Culture and Ceramics Museum. Oxen were pivotal in Chinese civilization and hold deep symbolic meaning in China. You'll have a rare, hands-on chance to study objects of high historical and artistic value.
- | | | |
|--------|--------------------|--|
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| 26-Oct | Guilin: | Drift down the Li River: bamboo rafting, village life |
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Misled Penguins

Young birds follow the right signal to foraging grounds, but when they arrive there are no fish to eat

In an **ecological trap**, natural cues lead animals to forage or breed in a place that is no longer beneficial, putting them at great risk. Since 2000 ecologists have identified more than two dozen such traps. They include polarized glints of sunlight that make glass look like water to insects. In early 2017 researchers revealed the first evidence of a trap in the ocean. Young African Penguins, an endangered species that breeds in South Africa and Namibia, seem hardwired to follow signals up the coast (*yellow lines*) in search of anchovies (*purple*) and sardines. Because those species are overfished, however, the food is not there—and 80 percent of the juveniles are dying.

Those who do survive manage to find their way south again. But then “they have chicks that will go and get stuck in the trap,” says ecologist Richard Sherley of the University of Exeter in England, who led the study. “It just becomes an extinction vortex.”

False Signal

Microscopic phytoplankton (*green*) emit dimethyl sulfide when they are eaten by typical predators such as larger zooplankton. Anchovies eat the zooplankton, so penguins follow the dimethyl sulfide cue to find their fish food. But the fish (*purple*) are no longer in the north, just in the south.

Penguin routes

Start End

Paths swum by 54 penguins tracked via GPS (shown simplified)

Concentration of chlorophyll—a pigment in phytoplankton (milligrams per cubic meter)

0-3 3-6 6-9 9-12 12+

Anchovy density (grams per square meter)

1-5 5-25 25-50 50-100 100-500 500+

▲ Penguins that swam toward the trap

▲ Penguins that swam toward anchovies

Hidden Feast

Anchovies thrive around the South African coast, although the phytoplankton signal still lures most penguins north toward Namibia.

Breeding Colonies

Some young penguins (*blue icons*) that left the nest found anchovies, but most (*black*) swam into the trap.

Ecological Trap

Juvenile penguins follow the phytoplankton signal (*green*) up the coast, but life-sustaining anchovies are no longer there, replaced by less nutritious goby. The penguins go hungry.

ATLANTIC OCEAN

SOURCE: “METAPOPULATION TRACKING JUVENILE PENGUINS REVEALS AN ECOSYSTEM-WIDE ECOLOGICAL TRAP,” BY RICHARD B. SHERLEY ET AL., IN CURRENT BIOLOGY, VOL. 27, NO. 4, FEBRUARY 20, 2017

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